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*Operation*

**SUN BEAM**

**SHOT JOHNIE BOY**

This document consists of 87 pages

No. 162 of 232 copies, Series A

PROJECT OFFICERS REPORT—PROJECT 1.1

**FREE-AIR AND FREE-FIELD BLAST PHENOMENA  
FROM A SMALL YIELD DEVICE (U)**

*J. H. Keefer, Project Officer*

R. E. Reisler  
C. N. Kingery

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Explosion Kinetics Branch  
Terminal Ballistics Laboratory  
Ballistic Research Laboratories  
Aberdeen Proving Ground, Maryland

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## ABSTRACT

The objectives of Project 1.1 were to record the overpressure and dynamic pressure versus time at selected distances along the surface as well as the overpressure versus time in free-air from the detonation of a subsurface, subkiloton nuclear device. The BRL self-recording gages and electronic recording systems were planned for both the surface level measurements and the free-air instrumentation which was suspended from a balloon. The balloon failed on D-1, and the free-air measurements planned by the project had to be cancelled. Based on the records obtained along the surface, it appears that the blast wave was nonideal from the 120 to the 260-foot station. The measured values fell below the predicted values from the 120 to the 560-foot station. The duration and impulse values also differed from predicted values from the 120 to the 260-foot station.

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## CHAPTER 1 INTRODUCTION

Participation in the Johnie Boy Shot of Operation Sun Beam was originally planned for the calendar year of 1963 as part of Operation Silverfox. Plans were changed, and the shot was included in the 1962 series. A revised proposal was submitted on 31 May, the first E and R plan was accepted by the Program Director on 5 June, and the shot was fired on 11 July. Johnie Boy was a subsurface, subkiloton shot. The predicted yield was 0.5 kt placed at a depth of 23 inches. The actual yield was 0.5 kt  $\pm$  .2 kt.

### 1.1 OBJECTIVES

The primary objectives of the Project 1.1 participation were:

- (1) To measure the overpressure and dynamic pressure along the surface from a subsurface, subkiloton device.
- (2) To measure free-air overpressure versus time from a subsurface, subkiloton device.
- (3) To integrate these results with existing blast phenomena.

### 1.2 BACKGROUND

The Department of the Army had indicated a requirement for information on the dynamic blast effects and the airblast phenomena resulting from the detonation of low yield weapons under various burst conditions. Existing blast information from subkiloton shots was extremely limited, being based primarily on four events during Operation Hardtack. As far as dynamic pressures were concerned, only three valid measurements were obtained from all the Hardtack events. Blast information from subsurface, subkiloton shots was essentially nonexistent. To permit reasonably accurate evaluation of damaging effects of subkiloton weapons, accurate information and/or prediction capability for the various blast wave parameters is required.

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To increase the knowledge of basic blast phenomena, investigations were required concerning the airblast associated with subkiloton detonations. Those investigations should have included both surface level and free-air measurements of both overpressure and dynamic pressure versus time. Free-air measurements on previous nuclear operations obtained only peak values of shock velocity and, subsequently by computation, overpressure. Pressure versus time histories would greatly enhance the state of knowledge and be directly applicable to vulnerability and safe delivery studies.

## CHAPTER 2

### PROCEDURE

The short preparation time allotted for this event plus the requirement to maintain full capability on two other events made it exceedingly difficult to insure a successful operation. The area was turned over to the project on D-7, and from that time to D-1 the recorders were installed, the gages calibrated and installed, and the balloon was launched complete with instrumentation by D-2.

#### 2.1 FREE-FIELD INSTRUMENTATION

A blast line was established southeast from ground zero starting at 65 feet and extending to a distance of 4000 feet. There were also two low-pressure gages located at the forward control point, a distance of 16,126 feet from GZ. Both the Ballistic Research Laboratories (BRL) self-recording gages and electronic recording systems were utilized to record the various parameters associated with the blast wave. There was a total of thirteen self-recording gages recording at surface level and three Q-gages recording at 3 feet above the surface. Two of the three Q-gages recorded side-on overpressure, as well as the total-head or stagnation pressure. There were nine electronic

gages mounted in ground baffles to measure over pressure along the surface, plus five total-head probes mounted at 3 feet above the surface. The blast line layout is shown in Figure 2.1.

2.1.1 Description of Self-Recording System. The self-recording system falls into three basic units, one being the sensing element, two the recording medium, and three the type of mounting utilized.

The sensing elements used on the Johnie Boy Shot are described briefly as follows:

(1) Capsule type sensor. The capsule type sensor is constructed of two concentrically convoluted metallic diaphragms nestled one inside the other to provide a minimum volume. They are welded together at the periphery, and one is silver soldered at the center to a mounting base. A light osmium-tipped spring stylus is soldered to the center of the free diaphragm. An increase in outside pressure entering through a small inlet causes expansion of the diaphragms. The diaphragm movement is recorded as a fine scratch on a coated recording disk. The amplitude of this scratch is the same as the movement of the diaphragms, which is proportional to the applied pressure. Proper dampening of the element is obtained through the use of an 80-mesh screen and the size of the orifice in the gage and sensor.

(2) Single diaphragm type. The single diaphragm type sensor, manufactured by U.S. Gage Company (USG), consists essentially of the top shell of the aforementioned capsule sensor, a convoluted metallic diaphragm with a stylus arm. A metal plate, flat on one side and contoured on the other side to match the contours of the diaphragm, facilitates the installation of the unit in a gage-recording system and provides for a minimum of volume between the plate and the sensor. A brass retaining ring fixes the diaphragm in position and provides an air tight seal with the aid of a thin nylon washer. An orifice in the contour plate provides the required damping. The gage recording system has a guide on one side of the sensor stylus arm to control lateral movement of the recording arm. Shown in Figure 2.2 is a photograph of the pressure sensors.

The recording medium used by the self-recording gage system consists of an aluminized glass recording disk or a vapor honed stainless steel disk rotated at a constant speed of 10 rpm by a chronometrically governed dc motor. The recording disks are centered on the gage turntable, with the coated side down, by a nylon or aluminum cone and held in position by a neoprene - ring coated retainer.

Initiation of the gage motor was accomplished by a hard-wire signal supplied by Edgerton, Germeshausen & Grier

(EG&G) at -2 seconds backed up at -1 second. The EG&G signal was distributed to each individual gage used on the test through a relay distribution box. A sensitive relay and power supply in the gage received the EG&G signal, electrically latched, and maintained continuity for the motor-power supply circuit. A star gear, cam-operated, cut-off switch, operated by the rotation of the turntable, opened the circuit controlling the number of revolutions that the turntable would make. A switch closure produced by an arming screw placed the gage in a ready state prior to evacuation of the area. Both the sensitive relay and power supply, along with the motor power supply, were mounted on a sheet metal base and coupled to the base of the gage frame with an Amphenol blue ribbon connector.

The frame making up the interior of the gage was a 4-inch steel H-channel, 8-inches long, welded to the center of a top plate, 1/2 by 8-1/4 inches in diameter.

The capsule and diaphragm gages are shown in Figures 2.3 to 2.5. The gage case was constructed of a 9-inch length of 5-inch diameter pipe, closed at the bottom with a 3-inch pipe cap welded to it. A flange 1/2 by 8-1/4 inches in diameter was welded to the top. In use, the gage was bolted to the top of the flange with a neoprene gasket, 1/8 inch in diameter, used to provide an airtight seal.



Field mounting of the gage, designated as the PHS gage, was accomplished by 3 methods. (1) The gage was buried with the flange flush with the ground surface. (2) The gage was screwed on a 3-inch diameter pipe nipple 8-inches in length with a 1/4-inch steel plate, 12 inches in diameter, welded to the end. This was implanted in the ground with the gage flange flush with the ground surface. (3) The gage was screwed on a 3-inch diameter pipe, 3-feet in length, which had previously been embedded in concrete. One-half inch steel welding rods were welded to the pipe at 1-foot intervals from the end to provide additional anchoring. See Figure 2.6 for a schematic of the mounts.

For all stations greater than 200 psi, a shock-mounted system, designated as the PHS-1S gage, was utilized. Figure 2.7 shows a schematic of the shock mounted unit. The mount case was cast of aluminum, while a stainless steel top plate was used. It is to be noted that rubber shock isolators were located in four equally spaced positions in the horizontal axis, and one isolator was located between the gage and the top plate. Figures 2.8 to 2.10 illustrate further the design of this system. Installation in the field was made by screwing the case on a 3-inch diameter pipe, 4 feet long, embedded in concrete. Due to the nature of the soil condition

in Area 18, a circular cardboard carton was utilized as a form for the mount and the concrete. The installed gage is shown in Figure 2.11.

The self-recording dynamic pressure gage used a diaphragm sensor (USG) to measure the stagnation pressure and a capsule sensor to measure the side-on pressure. A governed dc motor drove a vapor honed stainless steel disk at 10 rpm to record the deflection of the pressure sensors. The power supply for the motor, cut-off mechanism, and associated relay and power supply were mounted on a plastic base for installation in the mount stinger. The pressure sensors were mounted in two types of nose section: a rounded nose for lower pressures subsonic flow region and a tapered nose for higher pressures supersonic region. Shown in Figure 2.12 is a photograph of the nose section with the associated parts with the mounting stinger. Installation of the stinger with nose section was made on the standard dynamic pressure gage mount. A more detailed description of the gages will be found in (Reference 1).

2.1.2 Description of Electronic Recording System. The electronic recording system could be described in the same manner as the self-recording system in that it also consisted of three basic units: the transducer, the recorder, and the type mount used.

Transducers. There were four types of transducers used on this shot.

They are all commercially available and a brief description of each is contained in the following paragraphs.

(1) The Wiancko pressure gage is a proven, rugged, dependable gage which has been used extensively on many nuclear tests. It is a variable-reluctance type gage, where a change in pressure causes a proportional change in inductance. The pressure-sensing component of the gage is a twisted bourdon tube which tends to untwist when pressure is applied. A flat magnetic armature is fastened to the sealed end of the tube, and a rotation causes air gaps in the electromagnetic circuit to change, thereby changing the circuit inductance. This inductance change can be used to amplitude-modulate a carrier voltage to produce a signal as a function of pressure.

(2) The Detroit Controls pressure transducer utilizes strain elements bonded to a strain tube. A flush catenary diaphragm attached to the end exposed to pressure results in a minimum change in the volume of the pressure vessel. It also minimizes the effect of temperature changes on the output signal and maximizes the frequency response of the gage. Any change in pressure on the diaphragm results in a minute dimensional change of the strain tube, which is reflected by an equivalent resistance change in the strain gages bonded to the strain tube.

(3) The Dynisco pressure transducer is a four-active-arm bonded strain gage sensing element. The gage has a flush diaphragm and a natural frequency of up to 22,000 cps for the 1000-psi range gage. It is relatively insensitive to the effects of vibration and shock.

(4) The Micro-Systems pressure transducer utilizes solid-state strain elements bonded to the back of a 1/4 - inch diameter flush diaphragm. This is a miniature gage with a high output as well as exceptionally high natural frequency. Figures 2.13 and 2.14 show photographs of the gages.

Recorders. There were two types of recorders used for the free-field blast line measurements. Both recorders were manufactured by the Consolidated Electrodynamics Corporation (CEC) and are known as System D and System E.

(1) The System D recorder is a carrier-amplifier system capable of recording both static and dynamic inputs in the range of 0 to 600 cps frequency response. The principal of operation is suppressed carrier modulation, where the end result of the amplified gage signal is transmitted to an oscillographic recorder, and a permanent graphic record of the signal is made on photosensitive paper. The Wiancko transducers were used in conjunction with the System D recording system.

(2) The CEC System 1-127E also operates on the suppressed carrier-modulation principle and functions essentially

in the same way as the System D. The System E uses a carrier frequency of 20,000 cps to the transducer, with a band pass of 0 to 3000 cps, which permits a much higher frequency response from the gages to be recorded. The strain type transducers were used in conjunction with the System E recording system.

A photograph of the two recording systems, with all auxiliary equipment located in a field transportainer recording shelter, is shown in Figure 2. 15.

The mounts used for the electronic gages were all of the same general type. The primary difference was the distance from the top of the mount to the bottom. The mounts were constructed in position by first digging a trench the proper depth and erecting a plywood form 24 inches square and extending from the surface level to the bottom of the ditch. A gage adapter with a 2-inch flexible conduit was placed in the center of the column at the surface and extended out of the bottom into the cable trench. The plywood form was filled with concrete and allowed to set. The first four stations from 65 feet to 150 feet had an 8-foot mount. From 190 to 560 feet, a 6-foot mount was constructed. A detailed drawing of the mount is presented in Figure 2. 16.

A standard q-gage mount was used for the total-head, or stagnation, probes. The probe was mounted at 3 feet

above the surface, with the transducer located at the same radial distance as the ground baffle gage for a given station. The mount configuration is also shown in Figure 2.16.

2.1.3 Electromagnetic Pulse Protection. The electromagnetic pulse, which is peculiar to the detonation of nuclear devices, has been a major problem to instrumentation people because of the disturbance and damage caused to transducers and recording equipment. The pulse is so strong that unprotected strain gages are usually burned out from the high induced voltage. To protect against the damaging effects of the Electromagnetic Pulse, three precautions were taken.

(1) The output transformer from each System D oscillator power supply was shunted to ground by a 0.5  $\mu$ f condenser with a voltage rating of 400 volts. Since the pulse is a high-frequency alternating voltage, it tends to charge and discharge the condenser allowing only a small amount to pass through the transformer coils.

(2) The gage signal conductors were passed through normally closed contacts on telephone type relays, and in order to protect the gages and recorder galvanometers from the excessively high voltage induced in the gage signal conductors at time zero, it was necessary to open the circuit and ground the conductor.

This was accomplished through the use of a -2 second signal from EG&G, which powered a relay coil opening the circuit and grounding the conductor prior to time zero and the electromagnetic pulse. It was necessary of course to close the circuit to record information from the gages. This was done by using a photosensitive (blue box) device, which removed power from the grounding relays, thereby returning the circuit to normal before the arrival of the shock wave. The blue box was initiated from the flash associated with the detonation, and there was enough delay in the operation of the relays to assure that the electromagnetic pulse was over before the circuits from the gages to the recorders were closed.

(3) For added protection of the gages, spark gaps were used to drain off the induced voltage if it reached the breakdown point. The spark gaps were adjusted to break down at 750 volts. They were installed at each transducer station between the shield of the signal cable and a ground rod.

## 2.2 FREE-AIR INSTRUMENTATION

The major problem encountered in making overpressure versus time measurements in free-air is that of placing the transducer at the right point in space at the right time and with the correct orientation. An attempt was made to overcome the aforementioned problem through the procedures detailed in the following paragraphs.

2.2.1 Description of Balloon System. The problem of supplying and launching the balloon was contracted to the Sandia Corporation. The balloon was approximately 60 feet in diameter when filled. The outer cover was a heavyweight nylon material, while the liner was made of polyethylene, one-mil thick. The volume of gas used to fill the balloon was approximately 100,000 ft<sup>3</sup>. A measured lift capacity was recorded as 4600 pounds.

The anchor block directly below the balloon was located at 350 feet from ground zero. There were gages attached to this anchor line, which is noted as Pod Line B in Figure 2.17. The electronic gage line was located directly over ground zero and is designated as Pod Line C. It had a bearing from the main anchor block of 156 degrees. Pod Line A, which had self-recording gages attached, was located 456 feet from the anchor point on a bearing of 36 degrees. This placed the line a horizontal distance from ground zero of 700 feet. The height of the apex of the tether lines was 3000 feet above the surface.

The location of the electronic recording stations above ground zero is shown in Figure 2.18. The first station at 200 feet above the surface, had a gage in the side of the pod to measure the side-on over-pressure and one in the nose to measure stagnation pressure. The second pod at 400 feet above the surface had two side-on



gages, while the third and fourth pods at 800 and 1200 feet had one side-on pressure gage.

Pod Line B, located a horizontal distance of 350 feet from ground zero, is shown in Figure 2.19, with the location of the individual gages above the surface. Pod Line A, located 700 feet from ground zero, is shown in Figure 2.20. Here, the heights of the gages above the surface are noted.

2.2.2 Description of Self-Recording System. The self-recording system used for the airborne experiment is illustrated in the schematic shown in Figure 2.21. A miniature, self-recording, pressure-time gage was mounted inside a 12-inch diameter aluminum sphere of 1/2-inch wall thickness. Twenty-four 1-1/2-inch diameter pressure ports were located in an equally spaced arrangement around the surface of the sphere. A 1-1/2-inch diameter threaded solid aluminum stud, welded to the sphere shell, facilitated the installation of the gage, and a locking disc was used to secure the gage in place. An eyebolt was installed 90 degrees to the gage for connecting to the gage tether line. A 12-inch length of 1/4-inch steel cable was used as the connecting link between the sphere and the tether line. An access port cut in the top of the sphere provided access for installation of the gage. Shown in Figures 2.22 and 2.23 are photographs of the system.

For comparison with the airborne gages, one sphere system was mounted at a 3-foot elevation between two 3-inch pipes embedded in concrete at the 560-foot blast line gage station.

Two types of miniature gages were used in the system: A PNS gage and a PGS gage. The PNS gage used a governed negator spring-motor-recorder to record the deflection of a Bendix type diaphragm

sensor. Associated timing, initiation relay, and power supply were included in the gage canister. The PGS gage used a governed dc motor to drive a stainless-steel vapor-honed recording disk. A BDX (Bendix manufacture) type diaphragm sensor was used to sense the pressure and record on the disk. Associated power supplies, timing oscillators, and relays with cut-off cam and switches were mounted to the gage frame and installed in a canister. Figure 2.24 is an illustrated drawing of the BDX type diaphragm sensor. Figures 2.25 and 2.26 show the PNS and PGS gage, respectively. For further details on these gages, the reader is referred to the Small Boy, Project 1.1 report (Reference 1).

2.2.3 Description of the Electronic Recording System. The electronic recording system will again be described in three phases. They are the transducer, the recorder, and the mounts.

The transducers used were all of the strain gage type. They were the Dynisco, the Micro-Systems, and the Detroit Controls. These transducers have been described under Free-Field Instrumentation, which may be used as reference.

The recording system was a Weber Recorder Model 10-110. It is a seven-channel, wide-band, frequency-modulated, solid-state electronic recorder. The system was designed to record with fidelity under high acceleration and shock loading, as well as extremes in environment such as temperature and dust. One technique used by the designer to ruggedize the tape transport was to suspend it between two parallel flat plates in which all necessary shafts, bearings, and guides were supported in bores, which were matched-drilled in order to insure parallelism on all elements which the tape might contact. This tape transport also used flangeless reels, as shown in Figure 2.27, because the flanges were undesirable and the hoop tension forces involved in a normal pulling of tape provided compressive forces within the reel stack, which prevented layer-to-layer motion within

the environmental range specified. A third design approach unique to this transport was the primary drive mechanism. A continuous, seamless mylar belt was used to transmit driving forces from a capstan roller to the magnetic tape itself.

The tape transport and recorder is a complete package, as shown in Figure 2.28. The electronics associated with the recorder consisted of the following components.

- (1) A wide-band voltage controlled oscillator.
- (2) A reference oscillator.
- (3) A complete circuit logic for system start, calibrate, and run.
- (4) A dc-to-dc converter for regulated power to the recording electronics.
- (5) A 400-cycle inverter for power to the capstan motor in the tape transport.

All of the previously mentioned electronics were of solid-state design and of modular construction, with the components mounted on simple printed circuit boards with drawn can covers. These modules were readily removable from the system and greatly simplified the set-up time for calibration and tests. All module units, with the exception of the inverter and Fairchild DC Amplifiers, were completely interchangeable.

A major advantage to the field use of this system was that the complete system operated from a single 28-volt dc power source. The power requirement was a nominal 50 watts, readily available from simple batteries. An additional item which simplified the field use of this recorder was the ability to control the system during calibration with a simple extended contact closure. This provided the ability to rewind and playback at anytime, thereby greatly reducing the normal calibration time.

One of the most significant features of the system was the isolation and differential input circuitry of the wide-band voltage controlled oscillator. This provided great flexibility in the set-up of pressure and acceleration channels not available if single ended voltage controlled oscillators had been used.

The recorder was mounted in a light-weight, high-drag container designed to slow the descent of the recorder after the shot. The recorder was encased in a special shock-absorbing foam to minimize the effect of the deceleration at time of impact. The gage canisters were suspended beneath the recorder container and are described in detail in the following paragraph.

There were four gage canisters suspended above the GZ point. The first canister was designed to measure a head-on or stagnation pressure and a side-on overpressure. The second canister was designed to measure side-on overpressure with two gages, while the third and fourth canisters were designed to measure one side-on overpressure each. The physical dimensions of the canisters were 1.9 inches in diameter and 40 inches long. Each end of the canister had a 30-degree included angle cone to help streamline the air flow over the canister. The signal cables ran from each gage to the recorder, passing through the canisters along the way. The cable was enclosed in a fiberglass covering where it was exposed between the canisters.

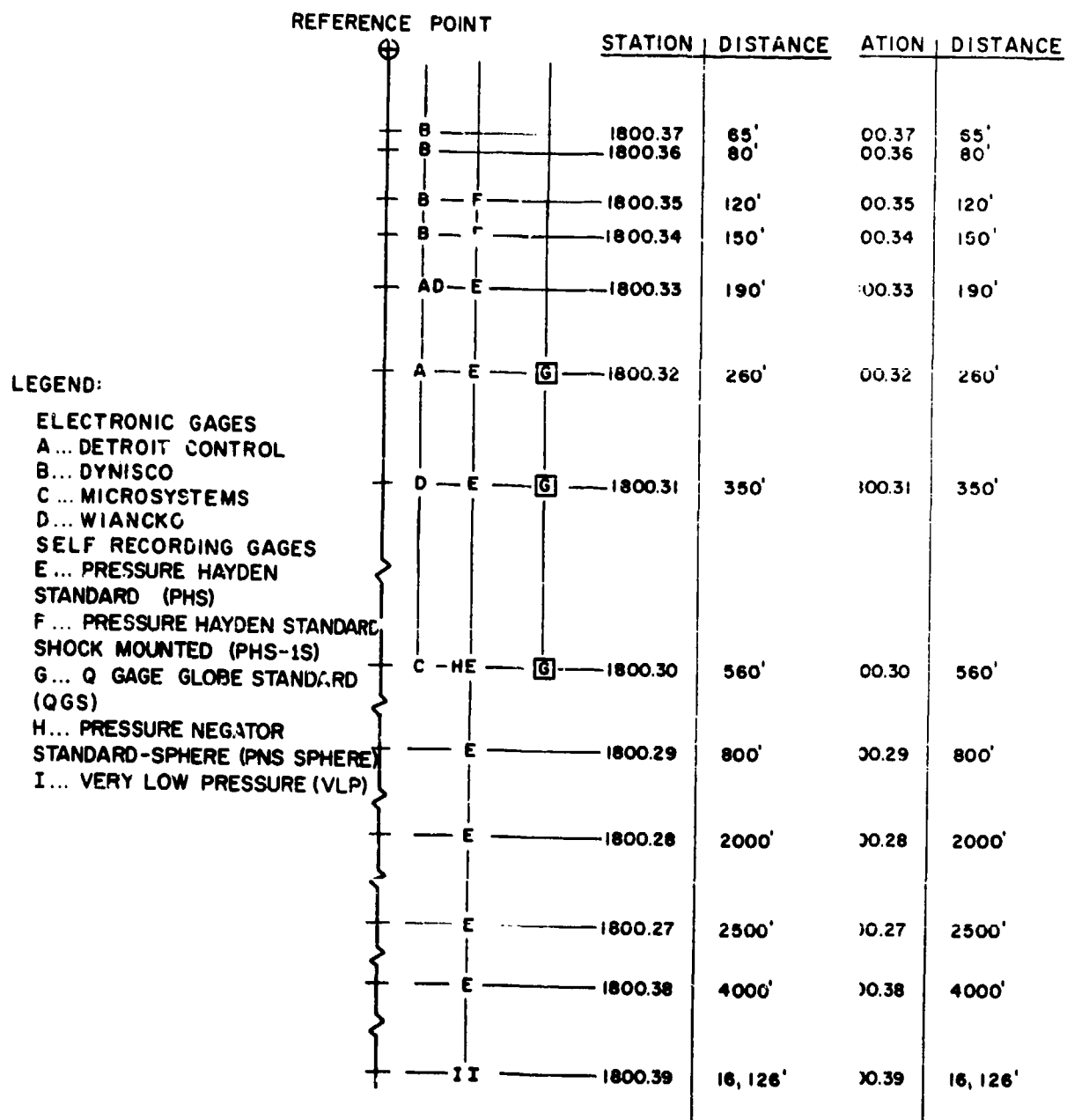


Figure 2.1 Blast line layout.

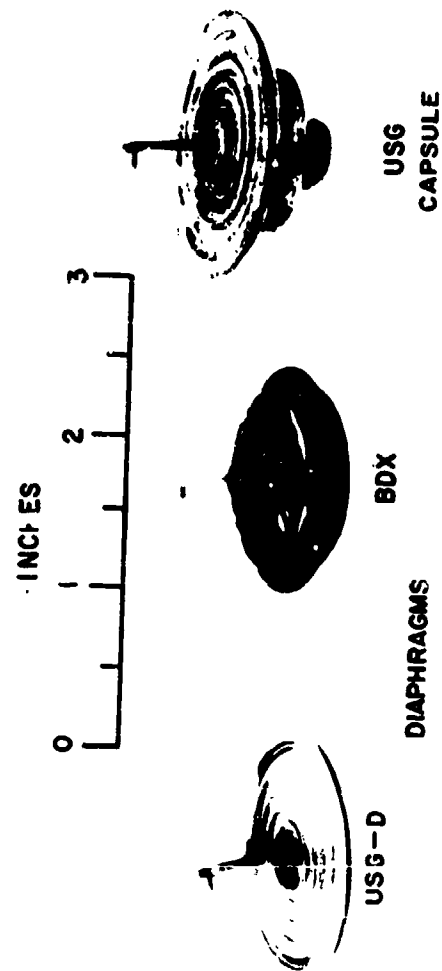


Figure 2.2 Pressure sensors, self-recording gage. (BRL photo)

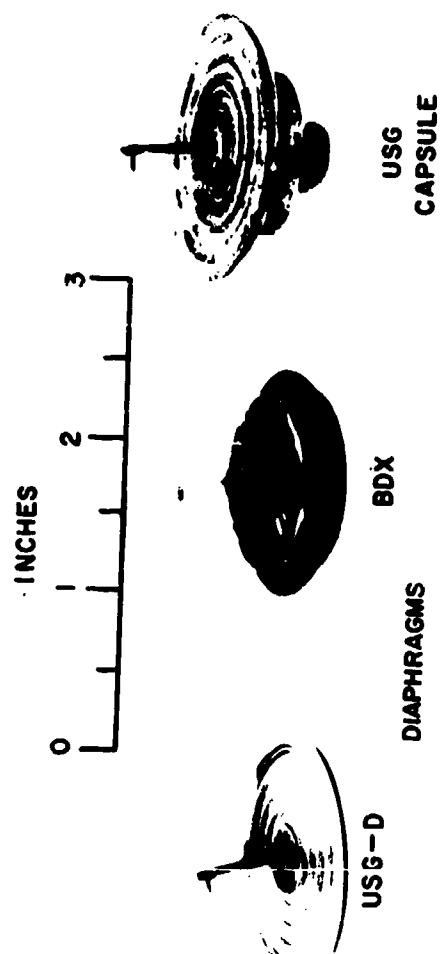


Figure 2.2 Pressure sensors, self-recording gage. (BRL photo)

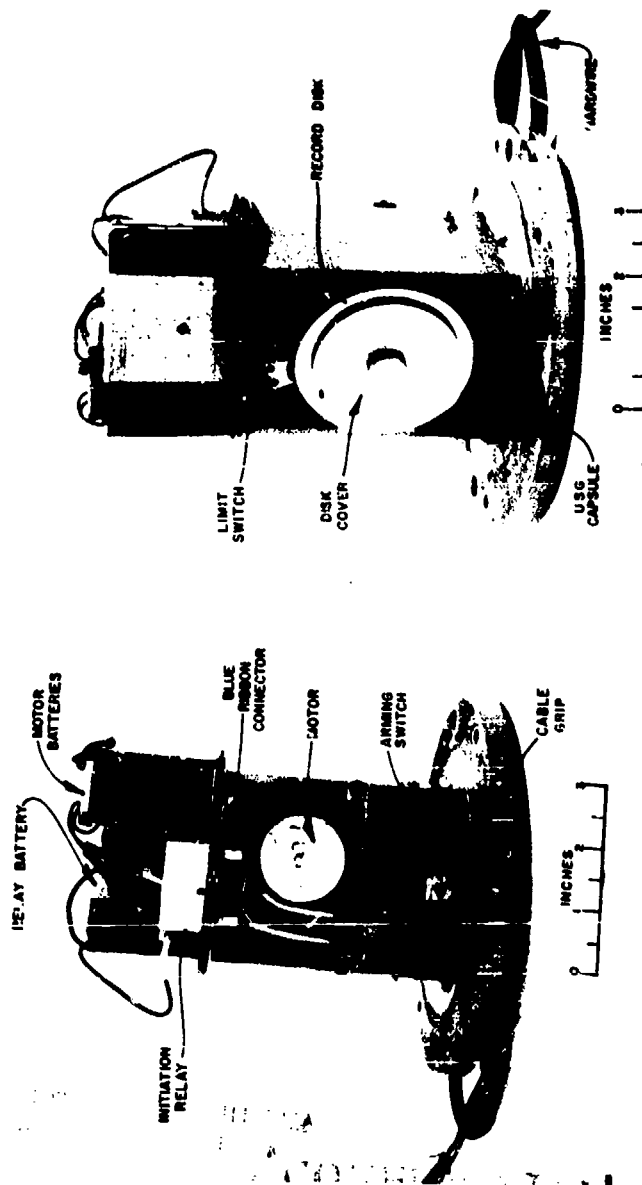


Figure 2.3 Detailed view of PHS gage. (BRL photo)



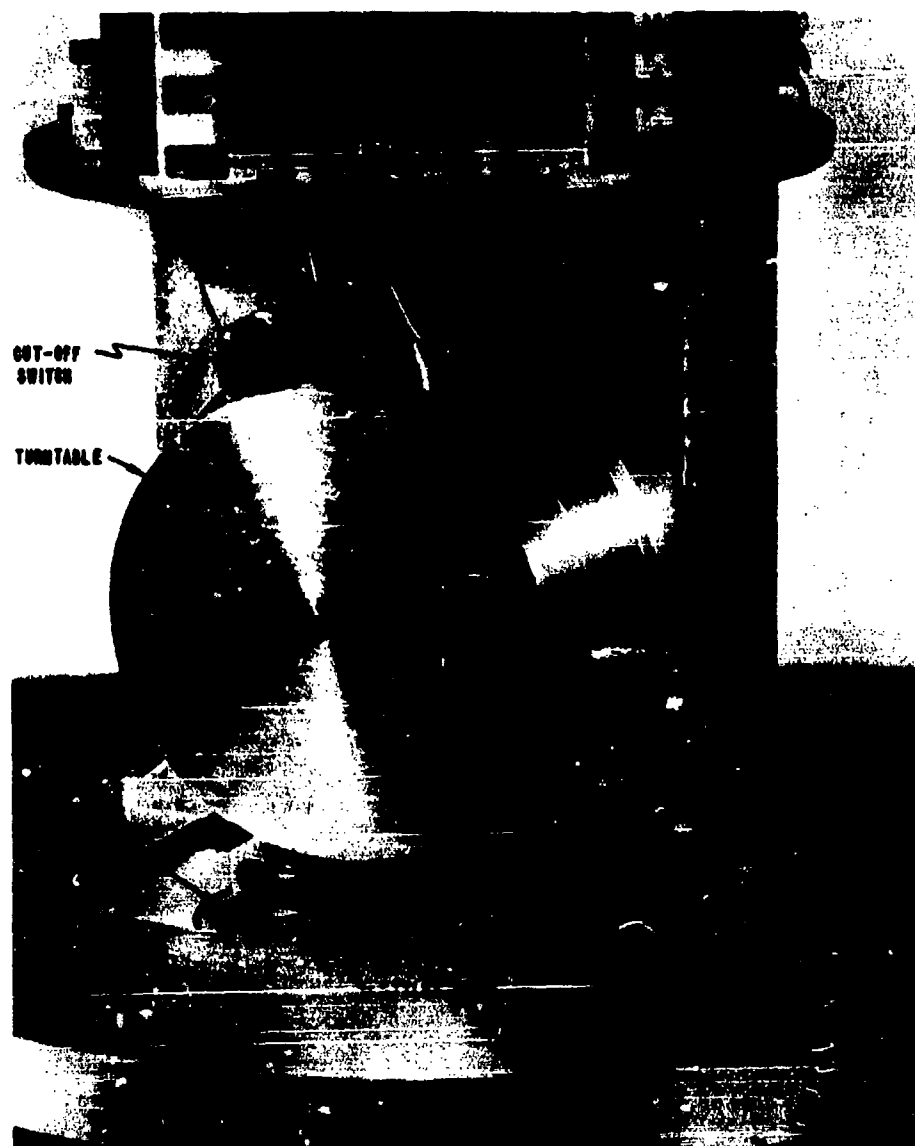


Figure 2.4 View of USG-diaphragm in PHS gage. (BRL photo)

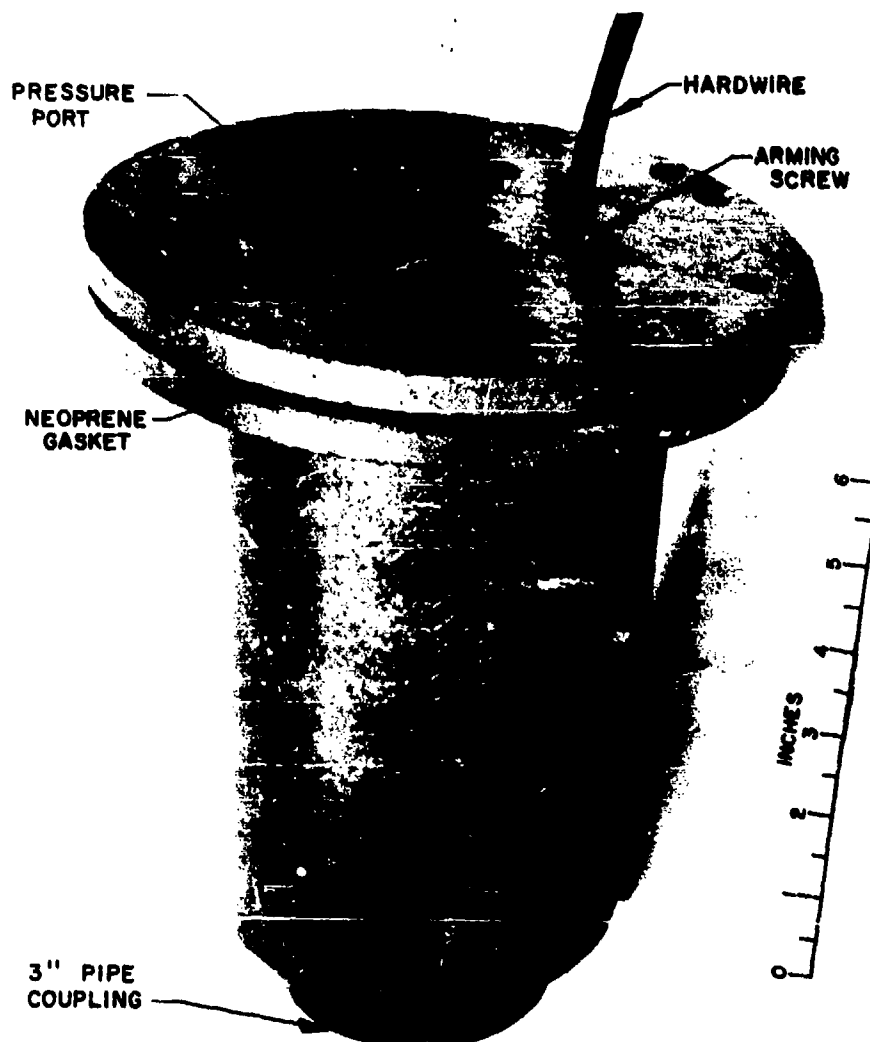
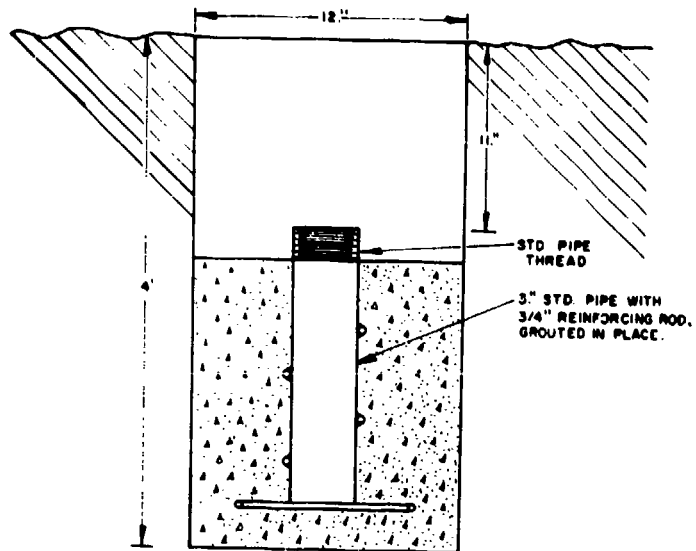
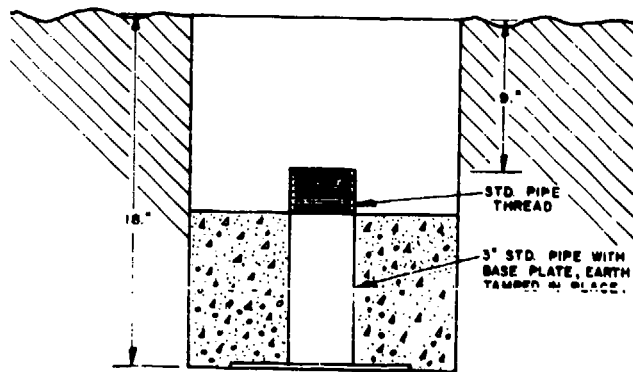


Figure 2.5 Assembled view of PHS gage. (BRL photo).

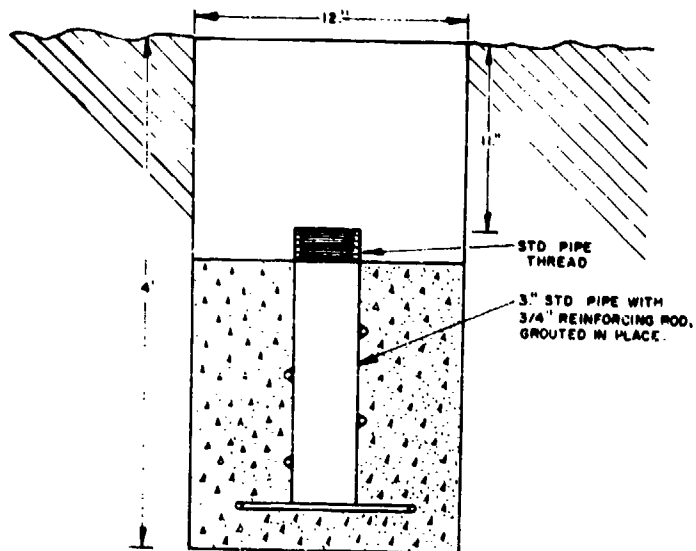


TYPE V - GAGE MOUNT (SELF-RECORDING)

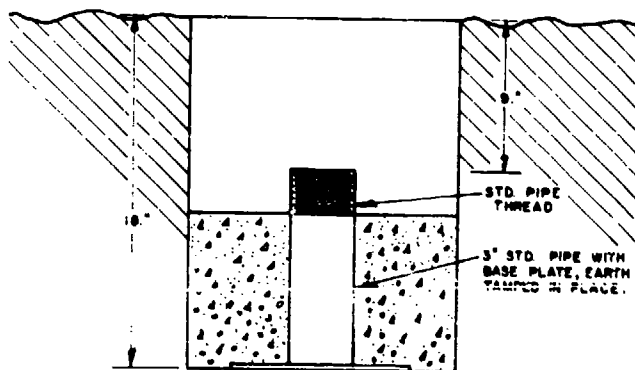


TYPE VI - GAGE MOUNT (SELF-RECORDING)

Figure 2.6 Gage mounts, Types V and VI.



TYPE V - GAGE MOUNT (SELF-RECORD)



TYPE VI - GAGE MOUNT (SELF RECORDING)

Figure 2.6 Gage mounts, Types V and VI.

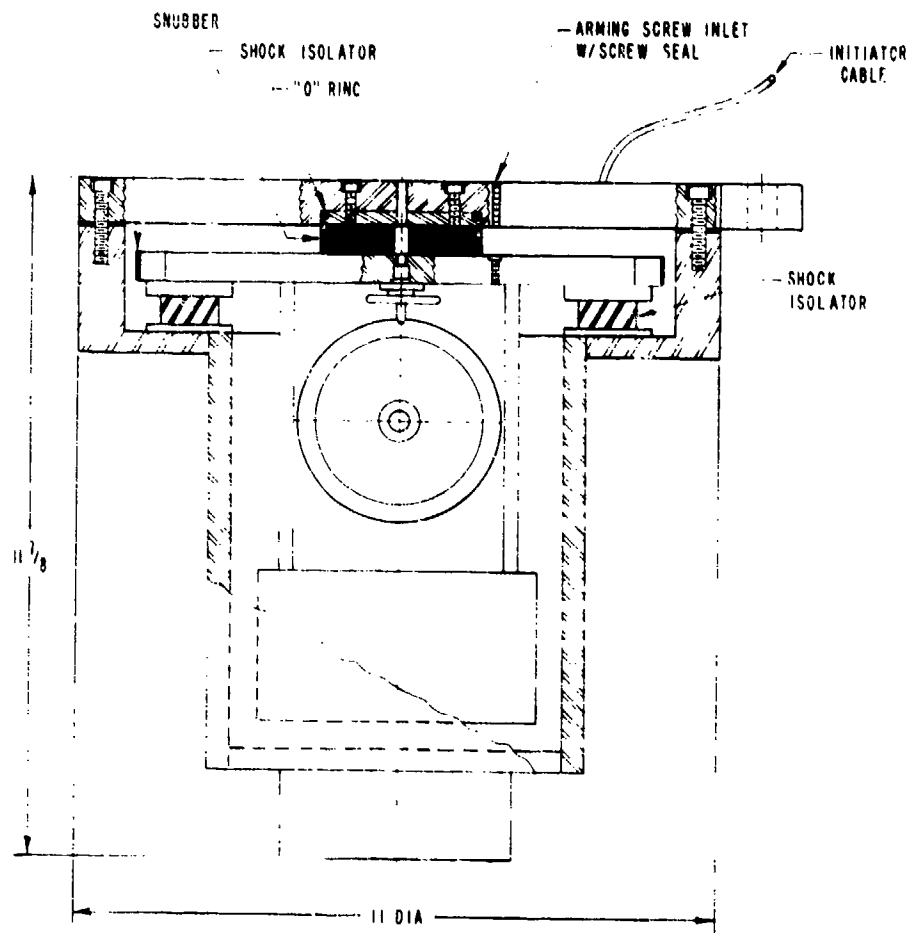


Figure 2.7 Schematic of PHS-1S gage.

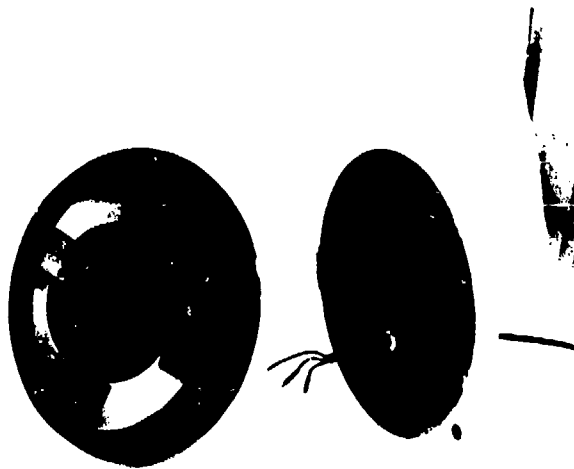


Figure 2.8 View of PHS-1S gage isolation system. (BRL photo)



Figure 2.9 View of PHS gage mounted on shock isolators. (BRL photo)

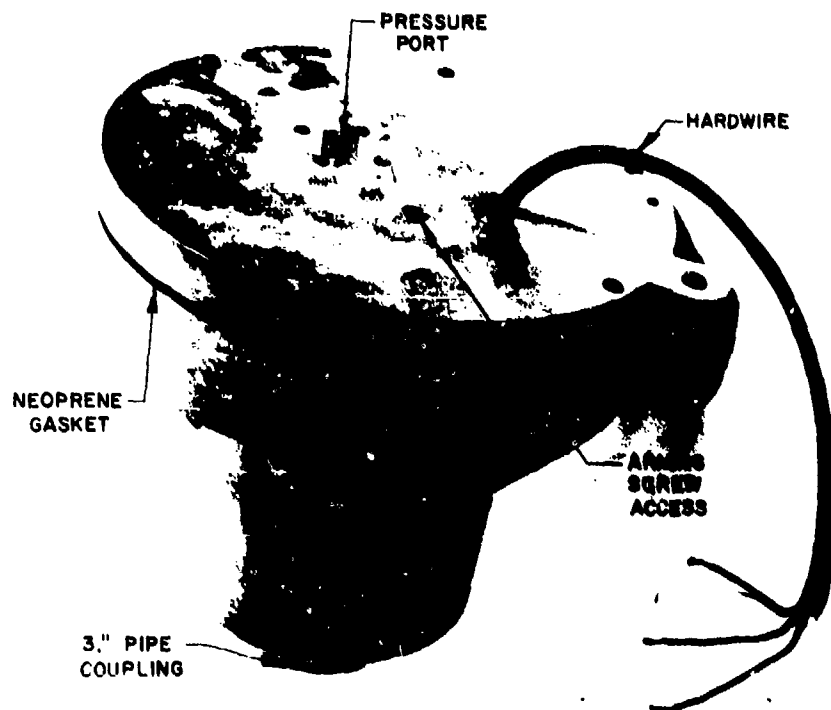


Figure 2.10 Assembled PHS-1S gage. (BRL photo)

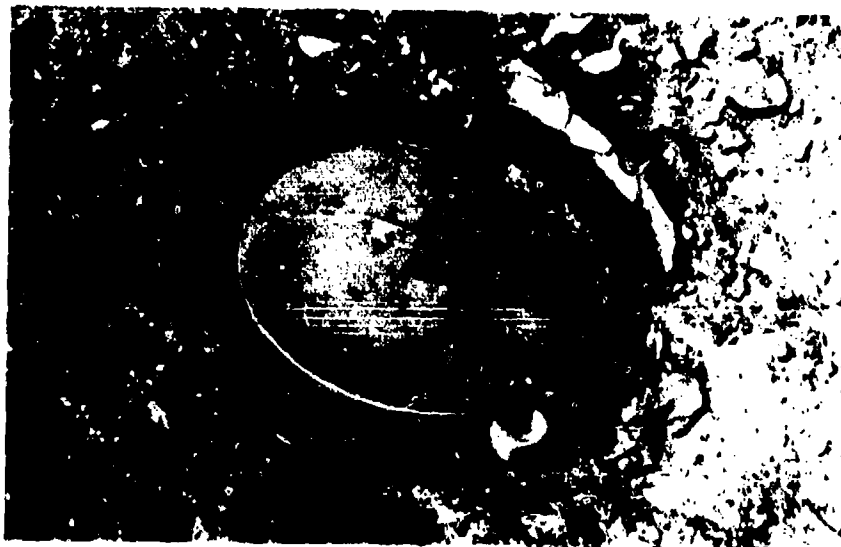


Figure 2.11 PHS-1S gage, field mounted. (BRL photo).

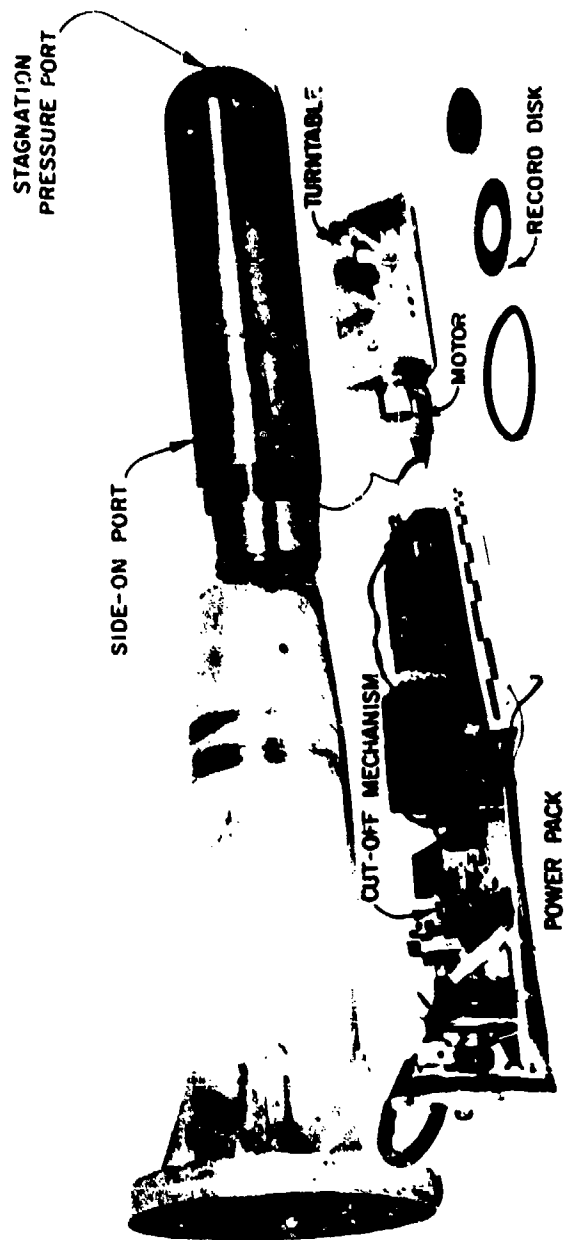
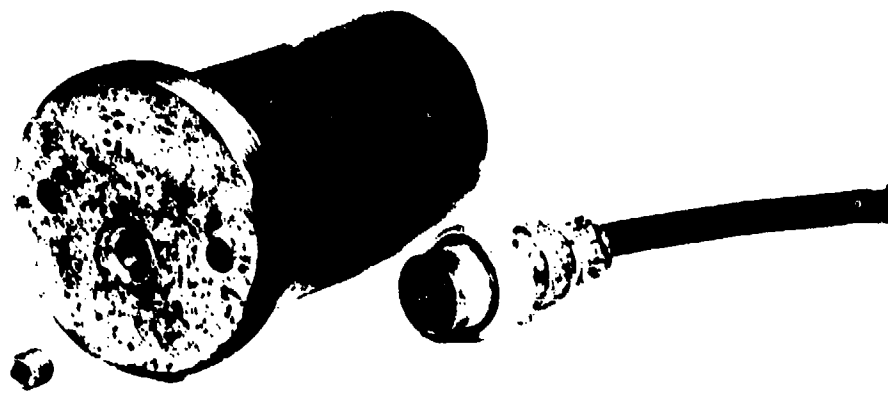
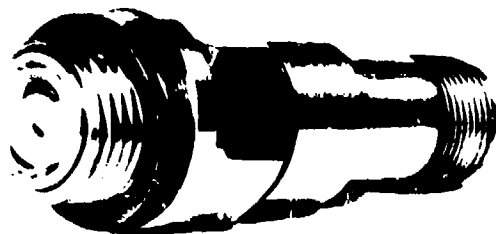


Figure 2.12 Detailed view of QCS gage. (BR photo)



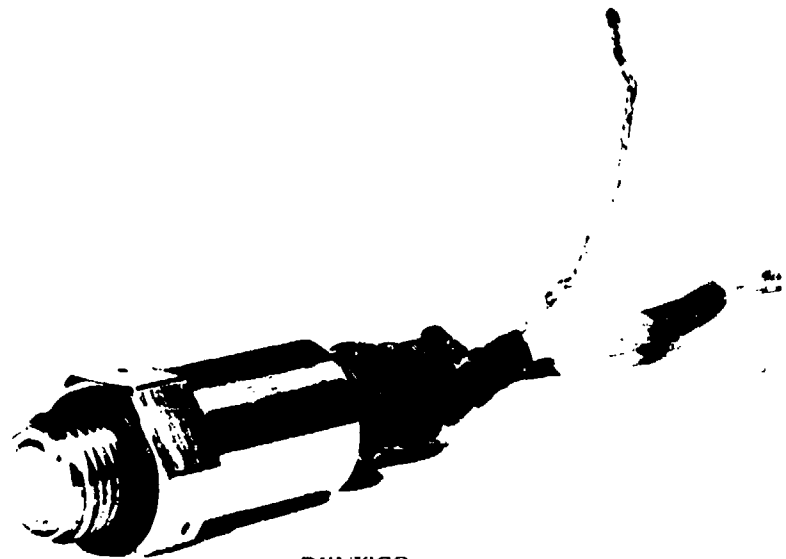


WIANCKO



DETROIT CONTROLS

Figure 2.13 View of Wiancko and Detroit Controls gages. (BRL photo)



DYNISCO



MICRO-SYSTEMS

Figure 2.14 View of Dynisco and Microsystems gages. (BRL photo)

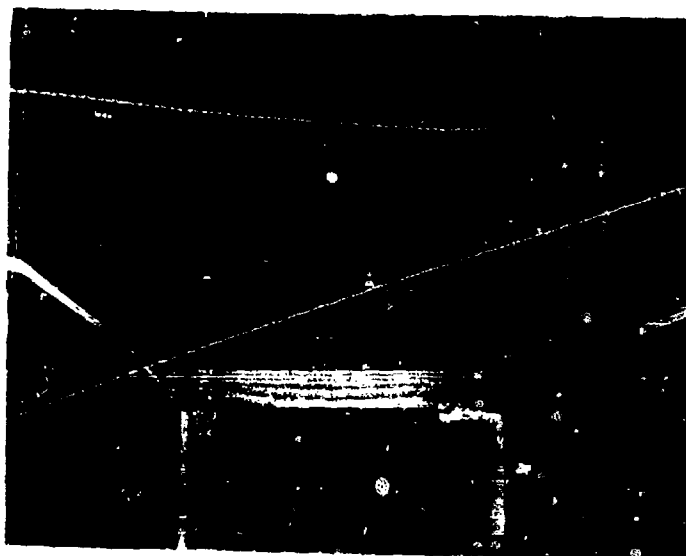
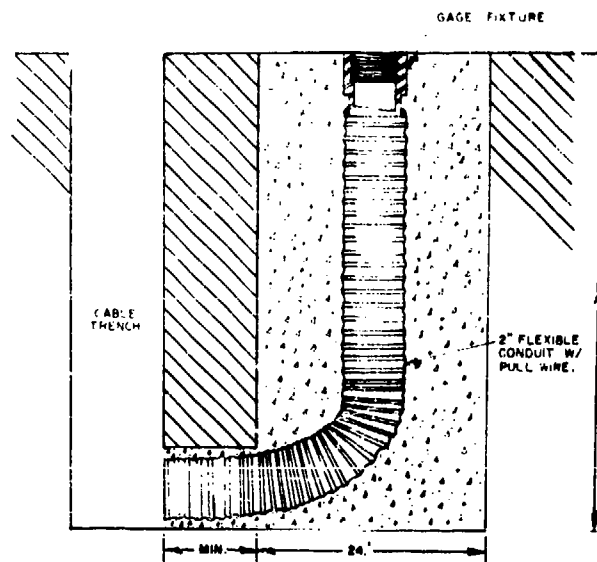
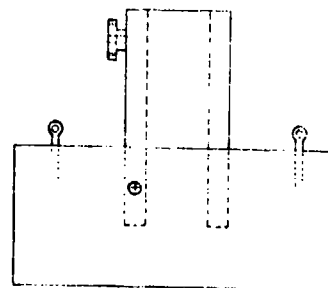


Figure 2.16 Field recorder shelter.  
(FCWT-DASA-665-26-NTS-62)



TYPE I GAGE MOUNT (ELECTRONIC) A = 8'  
TYPE II GAGE MOUNT (ELECTRONIC) A = 4'



TYPE III GAGE MOUNT (ELECTRONIC)  
(WITH PLL WIRE)  
TYPE IV GAGE MOUNT (SELF RECORDING)  
(WITH SAND FILLED PIPES & TOP ACCESS PORT)

Figure 2.16 Gage mounts, Types I through IV.  
(BRL photo)

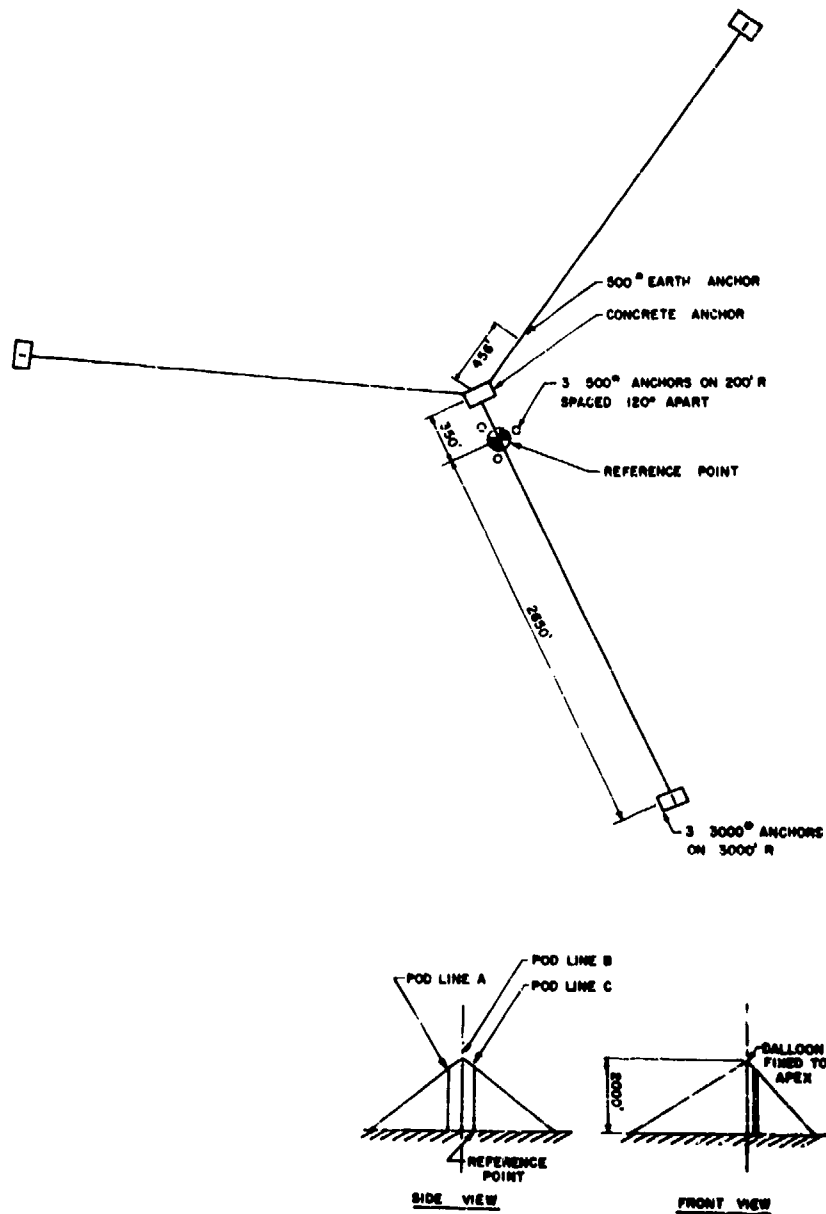


Figure 2.17 Balloon launching system.

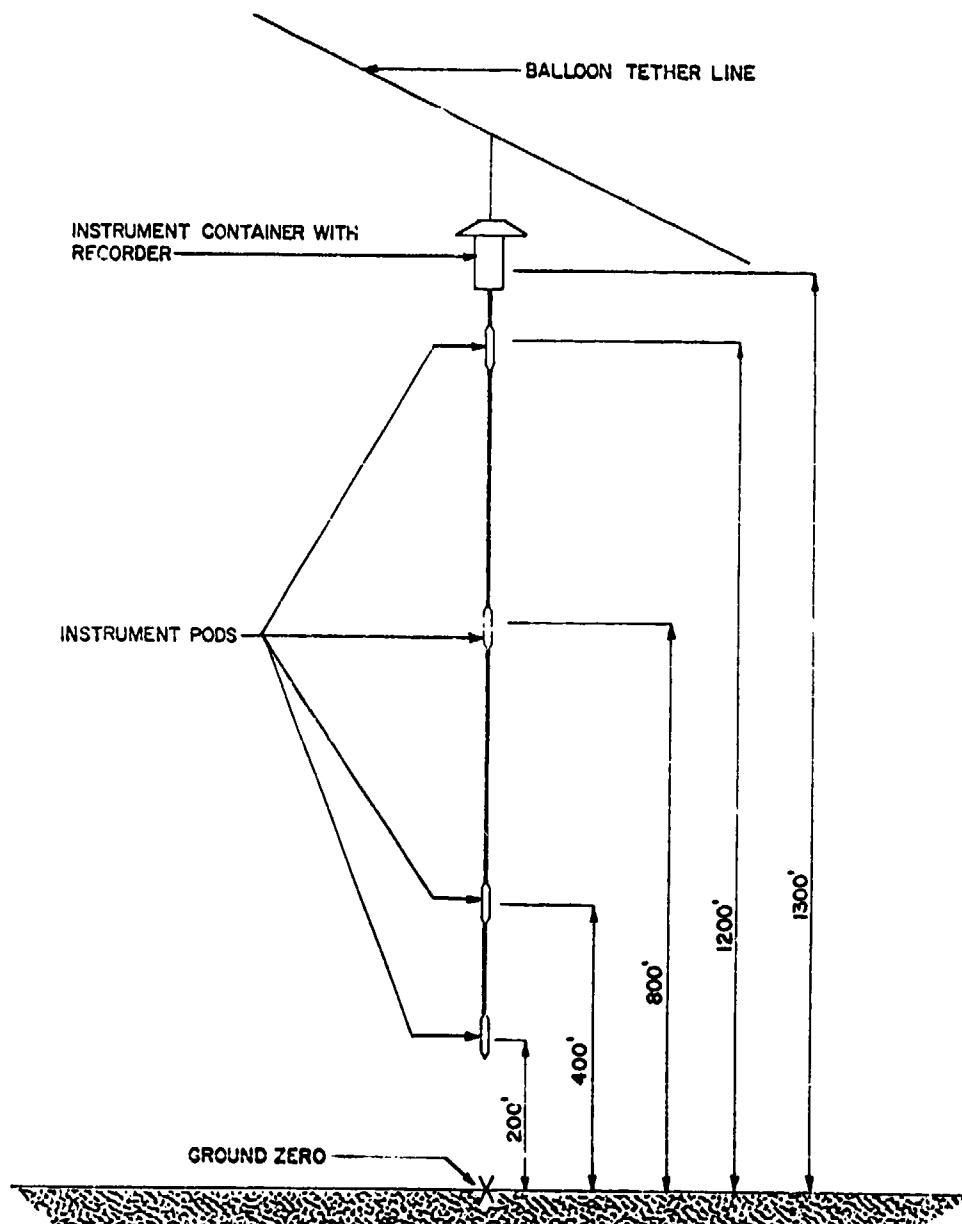


Figure 2.18 Pod Line C.

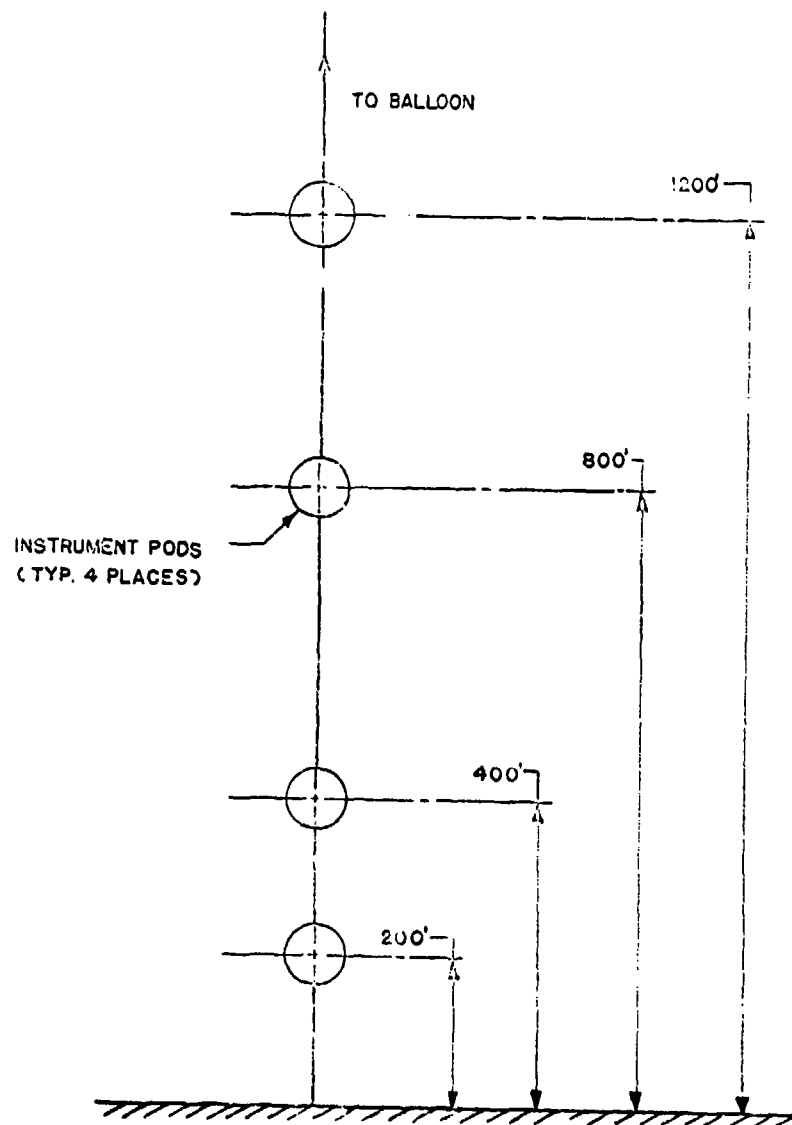


Figure 2.19 Pod Line B.

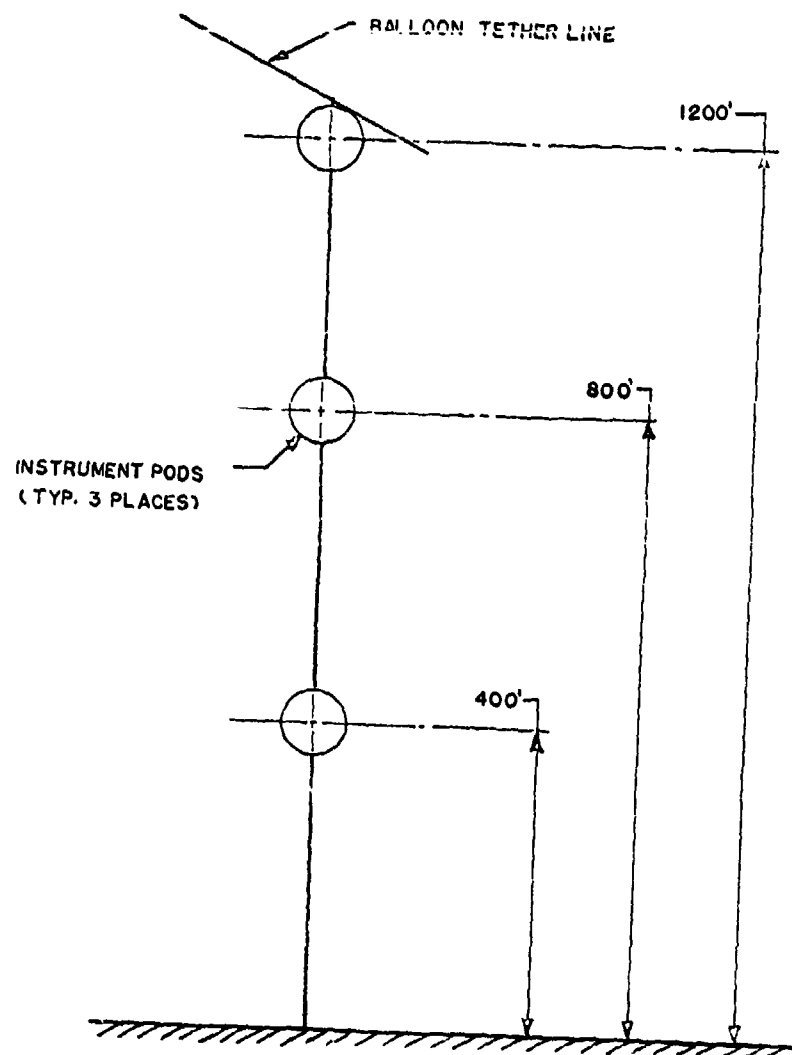


Figure 2.20 Pod Line A.



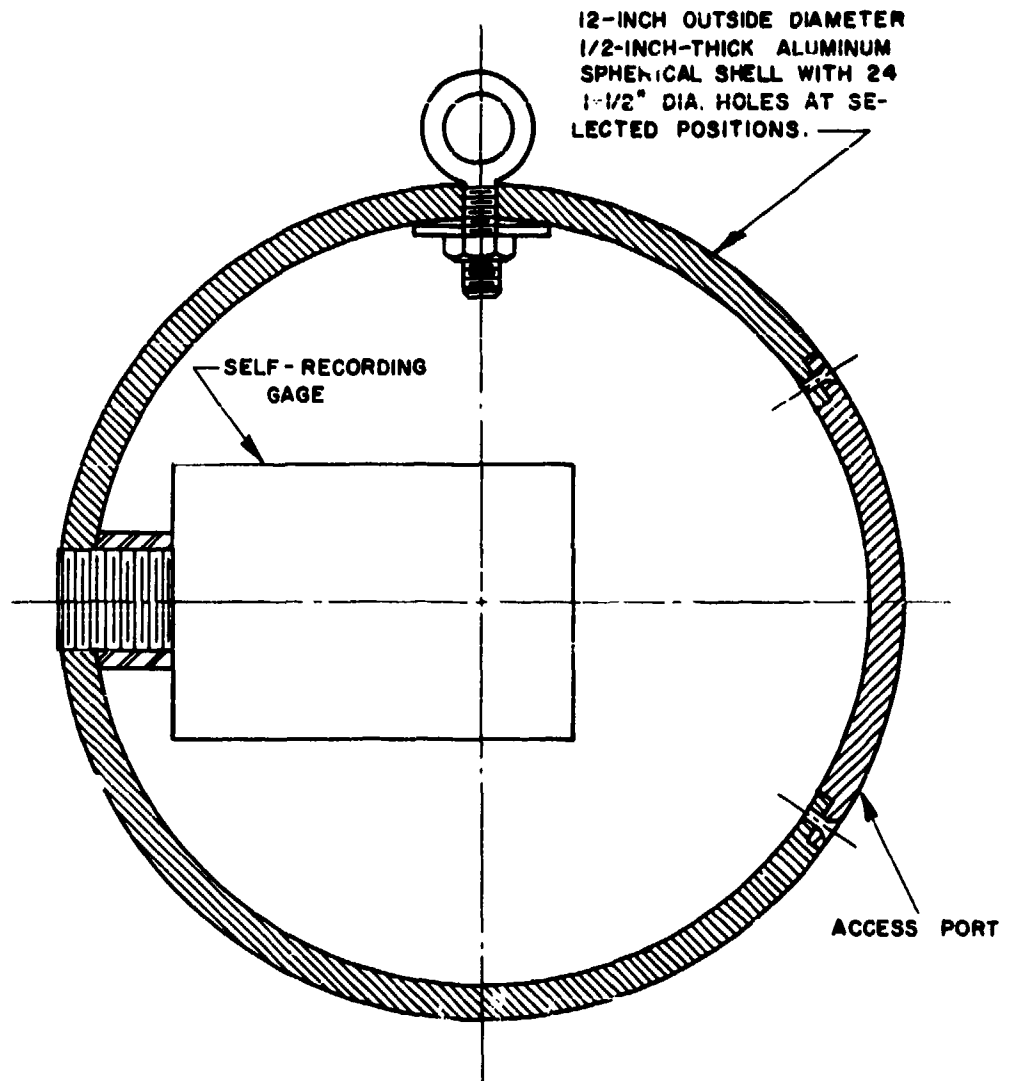


Figure 2.21 Schematic of SR airborne system.



Figure 2.22 Detailed view of airborne system.  
(BRL photo)

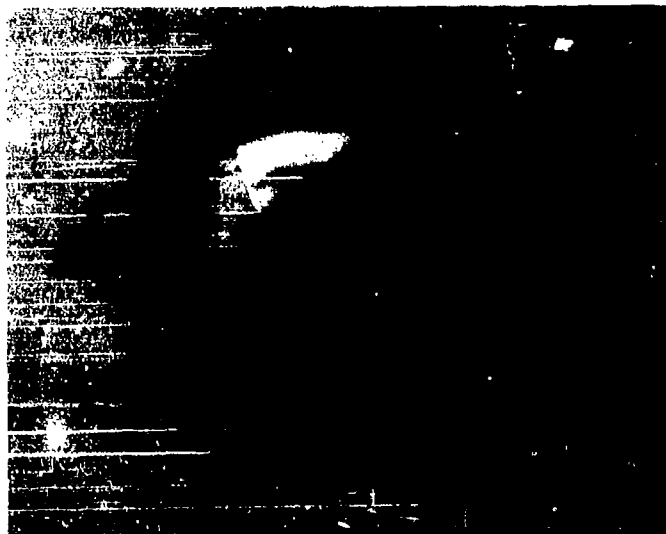


Figure 2.23 Assembled view of airborne system.  
(BRL photo)

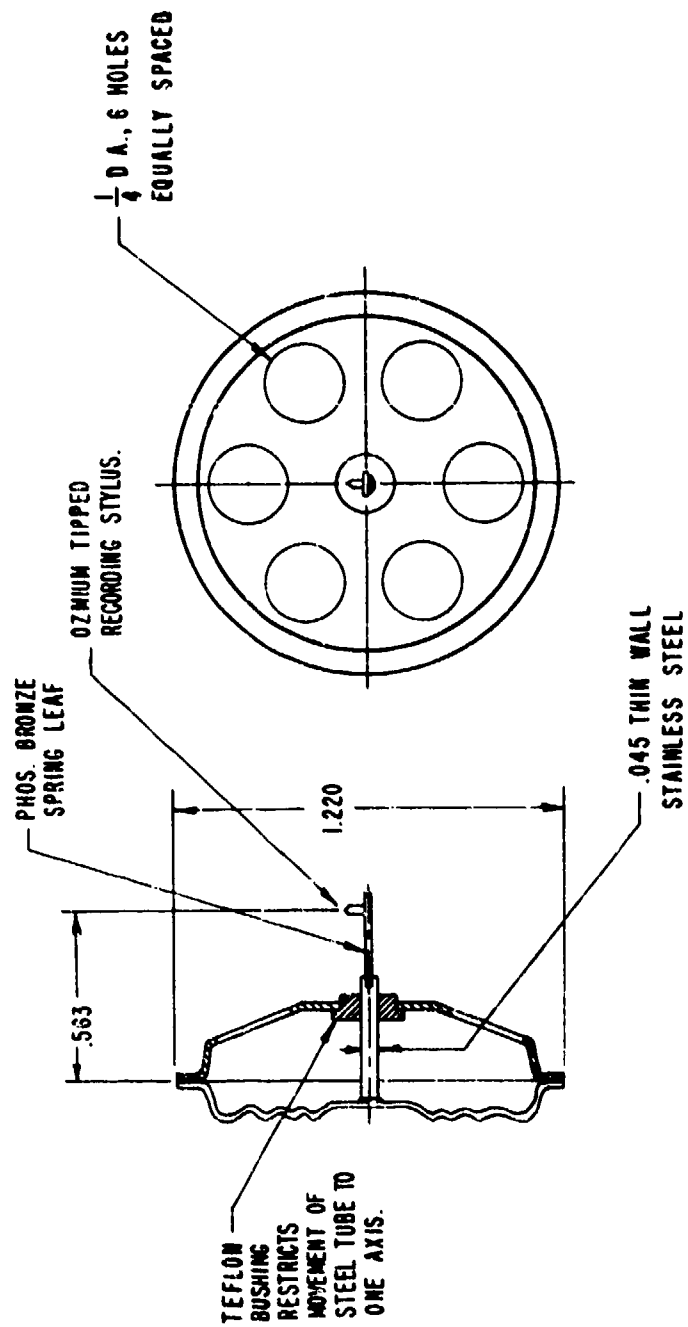


Figure 2.24 Schematic of BDX sensor (1 1/4-inch diaphragm blast sensor)...

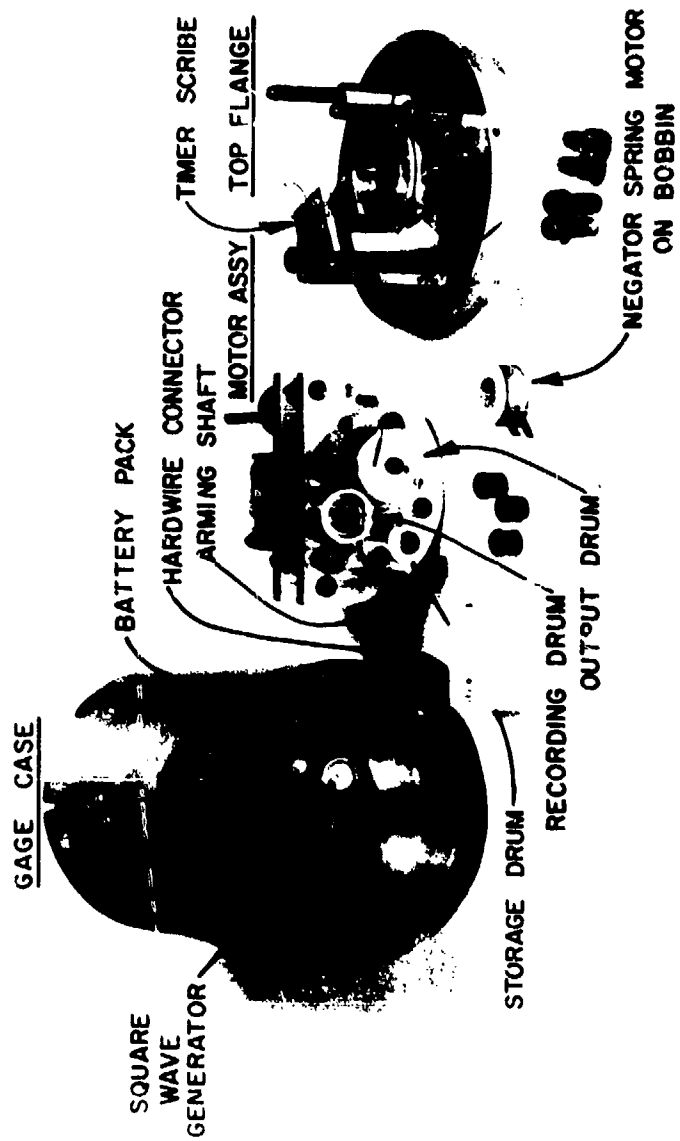


Figure 2.25 PNS gage. (BRL photo).

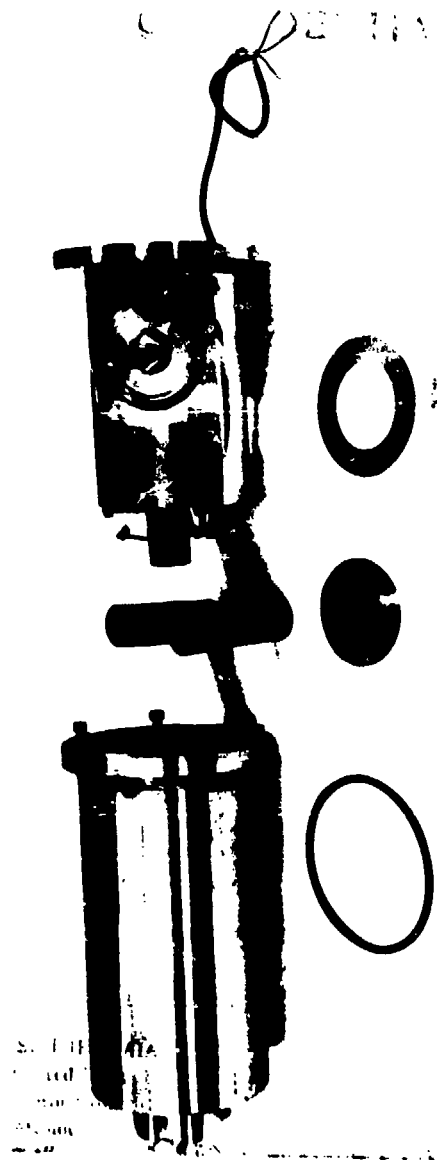


Figure 2.26 PGS gage. (BRL photo)

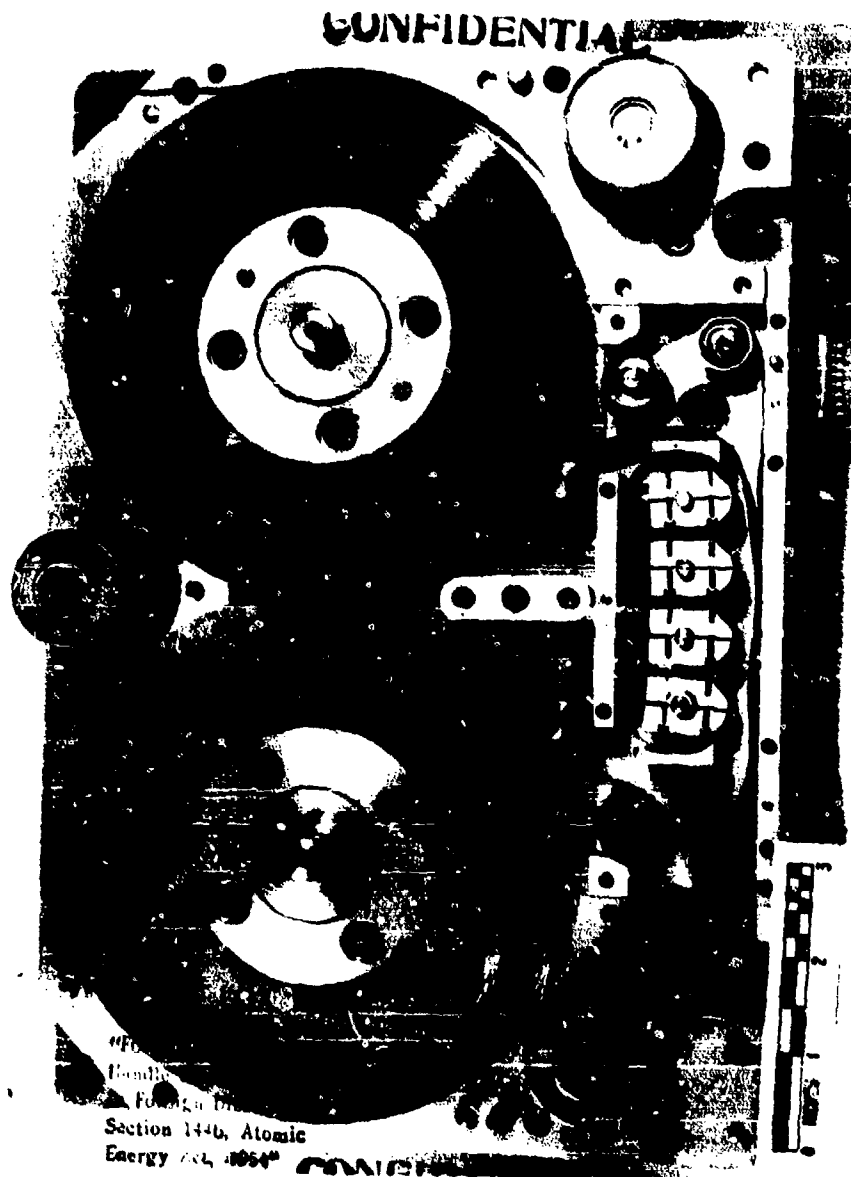


Figure 2.27 Weber tape recorder transport. (BRL photo)

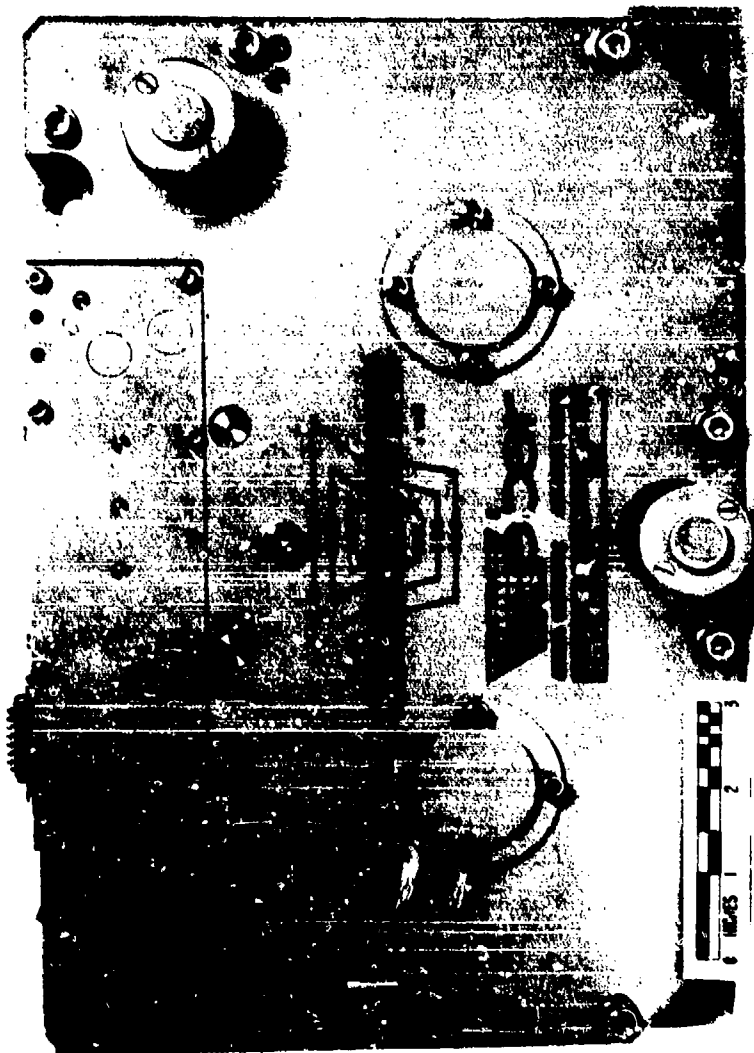


Figure 2.28 Weber tape recorder. (BRL photo)

## CHAPTER 3

### RESULTS

The presentation of results is divided into two parts. The first part will be concerned with instrumentation performance, and the second part will be a presentation of data in the form of tables and curves.

#### 3.1 INSTRUMENTATION PERFORMANCE

There was some loss of recording channels, but not all were due to instrumentation malfunction. The performance of the instrumentation was generally satisfactory, considering the field environment and the conditions under which it was used. The performance of specific transducers and recording systems will be discussed under the appropriate paragraphs.

3.1.1 Free-Field Instrumentation Performance. The free-field instrumentation fell into two categories. They were the self-recording systems and the electronic recording systems.

(1) The self-recording systems' overall performance was satisfactory and met the objectives of the project, with the exception of the dynamic pressure versus time measurements. Only a limited number of Q gages were available because they were used



on the Little Feller II shot and had to be recovered. Time was limited and a complete overhaul of the gages could not be made before installation on this shot. Only three dynamic pressure gages were installed, and one of these did not initiate although peak values were obtained.

All of the free-field ground baffle gages were recovered, and a statement relating to the quality of the individual records is noted in Table 3.1. The self-recording gages performed as programmed in most cases, and useful information was obtained. The shock mounting of the close-in gages was insufficient to attenuate the acceleration pulse to the most desirable levels. Adverse shock effects on the gage were noted by the partial pressure-time record at Station 1800.34. Failure apparently occurred in the electrical circuitry between the power pack and the motor. Modifications are being made in the shock isolation system to better attenuate the air induced acceleration.

(2) The electronic recording system used on this shot was far from ideal. The instrumentation consisted primarily of spare gages and recorders that were available from other shots. The electronic instrumentation phase of this project would not have been planned this way, but to meet the shot date many short-cuts had to be taken. It was necessary to run the timing signal cable along the surface of the ground rather than

in covered ditches. There was evidence that a truck ran over and cut one of these cables after project personnel had evacuated the area. Therefore, seven channels of electronic information were lost because the recorder ran preshot time. The seven channels of recording on the second recorder produced three good records, two peak-pressure values, and two were not readable. The good records were obtained from the CEC Recorder System D with Wiancko variable reluctance gages. The remarks column of Table 3.1 indicates the stations lost. A postshot check was made on the recovered gages, and the condition of each electronic transducer is noted in Table 3.2.

3.1.2 Free-Air Instrumentation Performance. The free-air instrumentation consisted of tethered balloon, with both self-recording gages and electronic gages. A brief description of the performance of the free-air instrumentation can be summed up with a statement that the balloon failed on D-1, and this phase of the project was cancelled. There was an operational requirement for the balloon to be launched complete with instrumentation and in a state of readiness by D-2. This was accomplished, but because of excessively high winds on D-1, a tether line broke. This allowed the balloon and instrumentation line to whip more violently until a signal line shorted causing the primacord to detonate and destruct the balloon. All airborne equipment fell to the ground. One important bit of information gathered was that the instrumentation withstood the free fall to the surface and that the magnetic tape recorder container had sufficient drag and foam protection for the recorder, which survived the fall.

### 3.2 PRESENTATION OF DATA

The presentation of data from the Johnie Boy shot will be primarily in the form of tables and plotted curves. Discussion and comparisons with scaled values will be presented in the following chapter.

Free-Field Air Blast. The recorded values of overpressure, arrival time, positive duration, and impulse are listed in Table 3.1, along with comments on the quality of the records.

(1) The peak overpressure versus distance values are plotted in Figures 3.1 and 3.2. The first two values are from partial records, since the latter portion of the pressure-time record was lost. As noted in Table 3.2, the transducer used at Station 1800.37 was so deeply buried by the crater lip that it was damaged just after the arrival of the shock front. The transducer installed at the second station (1800.36) was recovered and found to be shorted to ground. It is surmised that this damage also occurred after the shock passed over the gage, and here again only a peak overpressure was recorded. The overpressure records from the next two stations (1800.35 and 1800.34) are classified as poor records. They were recorded, using prototype shock isolation (PHS-IS) self-recording gages. There is some question concerning the validity of the wave shape and overpressure recorded at Station 1800.35. High acceleration at Station 1800.34 caused the

drive motor to stop, and therefore only a partial pressure-time record was recorded. The electronic overpressure versus time recorded at Station 1800.33 was considered valid, and it should be noted that it is a nonclassical type wave shape. The wave shapes recorded on the self-recording gage at the 1800.33 station, as well as the 1800.32 station, are considered questionable. The pressure versus time records are presented in the Appendix and are identified by station number, distance from ground zero, and either cable number for electronic transducers or capsule number for self-recording gages.

(2) The arrival time of the shock front at the various stations is plotted in Figure 3.3. The first three values appear to fit a smooth curve, but there is some apparent scatter to be noted at the last two stations. The value measured at Station 1800.31 was obtained from the same recorder as the three preceding values, while the value from Station 1800.29, located at 800 feet, was recorded by a self-recording gage.

(3) The durations of the positive overpressure recorded at gage stations along the blast line are plotted in Figure 3.4. The general trend of duration versus distance is quite similar to that established on the multi-ton high explosive (TNT) shots detonated in Canada (Reference 2).

(4) The positive impulse values calculated from the pressure versus time records are plotted in Figure 3.5. There is some scatter in the values plotted, but this was expected since there was also scatter in the overpressure and duration values.

(5) The peak dynamic pressure versus distance values are listed in Table 3.3 and plotted in Figure 3.6. These values were obtained from the self-recording gages, and the records are classified as of poor quality. Therefore, the values plotted should be considered accordingly. There were five electronic q-gage probes installed and three self-recording q-gage probes. Three of the five electronic gage channels were on the recorder that ran preshot time. The gage at Station 1800.34 could not be read, and the gage at Station 1800.31 produced an erroneous record. The data recorded from the self-recording gages were poor because of the high acceleration received by the gage mounts. This produced records that were very questionable and considered not valid for any dynamic pressure versus time presentations.

TABLE 3.1 AIR BLAST OVERPRESSURE RESULTS

Station Number	Horizontal Distance	Maximum Overpressure	Arrival Time	Positive		Gage Type	Cable or Capsule No.	Remarks
				insec	msec			
ft. psi msec psi-msec								
1800.37	65	16000	9.5	---	---	Dy	255	Initial peak only
1800.36	80	6350	10.4	---	---	Dy	256	Initial peak only
1800.35	120	---	---	---	---	Dy	261	*
	120	379	---	21	5707	PHS-1S	1000-1126	Poor record
1800.34	150	---	---	---	---	Dy	264	*
	150	232	---	---	---	PHS-1S	800-1131	Poor record
1800.33	190	138	26.5	62	1551	W	253	Good record
	190	---	---	---	---	DC	260	*
	190	117	---	73	2787	PHS	200-1047	Fair record
1800.32	260	---	---	---	---	DC	251	Non readable record
	260	57	---	101	1404	PHS	150-1017	Non-ideal wave shape
1800.31	350	44	116	---	---	W	259	Poor positive duration
	350	34	---	110	841	PHS	100-977	Good record
1800.30	560	---	---	---	---	MS	257	*
	560	15.2	---	139	754	PHS	25-1	Good record
1800.29	800	9.1	195	180	547	PHS	15-704	Good record
1800.28	2000	---	---	---	---	PHS	15-691	No record
1800.27	2500	1.4	---	---	---	PHS	15-116	Peak only
1800.38	4000	0.77	---	372	121	PHS	1-192	Good record
1800.39	16126	0.103	---	---	---	VLP	65	Peak only
	16126	0.120	---	482	82	VLP	66	Partial record

Note #:

\* Indicate channels lost because recorder was initiated preshot time.

TABLE 3.2 JOHNNIE BOY POSTSHOT GAGE INSPECTION

Station Number	Type Gage	Serial Number	Type Mount	Type Recorder	Gage Face	Gage Bridge
1800.37	Dyn	13520	A	20 KC	Not recovered	
					Buried	
1800.36	Dyn	13428	A	20 KC	OK	Short to ground
1800.35	Dyn	13429	Q	20 KC	OK	Damaged
	Dyn	9372	A	20 KC	OK	OK
1800.34	Dyn	13059	Q	20 KC	OK	OK
	Dyn	15327	A	20 KC	OK	Open
1800.33	W	10253	C	SyD	N/A	OK
	DC	5254	A	20 KC	OK	OK
	DC	5035	Q	20 KC	OK	Open
1800.32	DC	5314	A	20 KC	OK	OK
	DC	5210	Q	20 KC	OK	Open
1800.31	W	10208	C	SyD	N/A	OK
	W	10196	Q(50)	SyD	N/A	OK
	W	10120	Q(10)	SyD	N/A	OK
1800.30	MS	478	A	20KC	OK	OK

Note:

Station 1800.36 - Mount turned 30 degrees and tipped 15 degrees.

Station 1800.35 - Probe bent.

Gage bridge open means a loss of continuity and possible internal damage.

Dyn = Dynisco Pressure Transducer

DC = Detroit Control Pressure Transducer

MS = Microsystems Pressure Transducer

W = Wianco Pressure Transducer

A or C = Ground Baffle

Q = Probe

TABLE 3.3 DYNAMIC PRESSURE RESULTS

Station Number	Horizontal Distance	Maximum Pressure	Type Measurement	Cable or Capsule No.	Remarks
	ft	psi			
1800. 35	120	----	Stagnation	262	*
		----	Side-on	261	*
		----	Dynamic		
1800. 34	150	----	Stagnation	263	Non-readable
		----	Side-on	264	*
		----	Dynamic		
1800. 33	190	----	Stagnation	250	*
		----	Side-on	260	Non-readable
		----	Dynamic		
1800. 32	260	----	Stagnation	258	*
		----	Side-on	251	Non-readable
		----	Dynamic		
		145	Stagnation	400-5	Non-ideal wave shape
		60	Side-on	100-984	Non-ideal wave shape
		74	Dynamic		
1800. 31	350	----	Stagnation	150-4	Non-readable
		32	Side-on	100-966	Peak only
		----	Dynamic		
1800. 30	560	24.0	Stagnation	25-4	Poor record
		15.2	Side-on	25-1	Good record
		8.5	Dynamic		



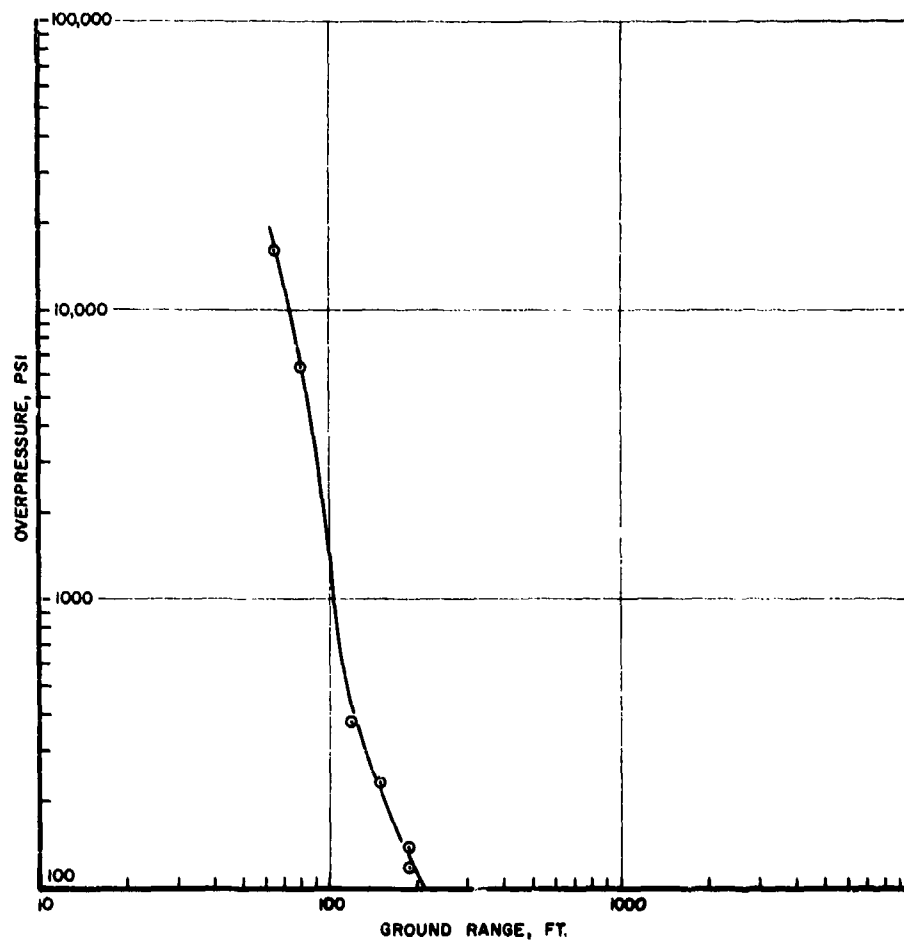


Figure 3.1 Overpressure versus ground range (18,000 to 100 psi).

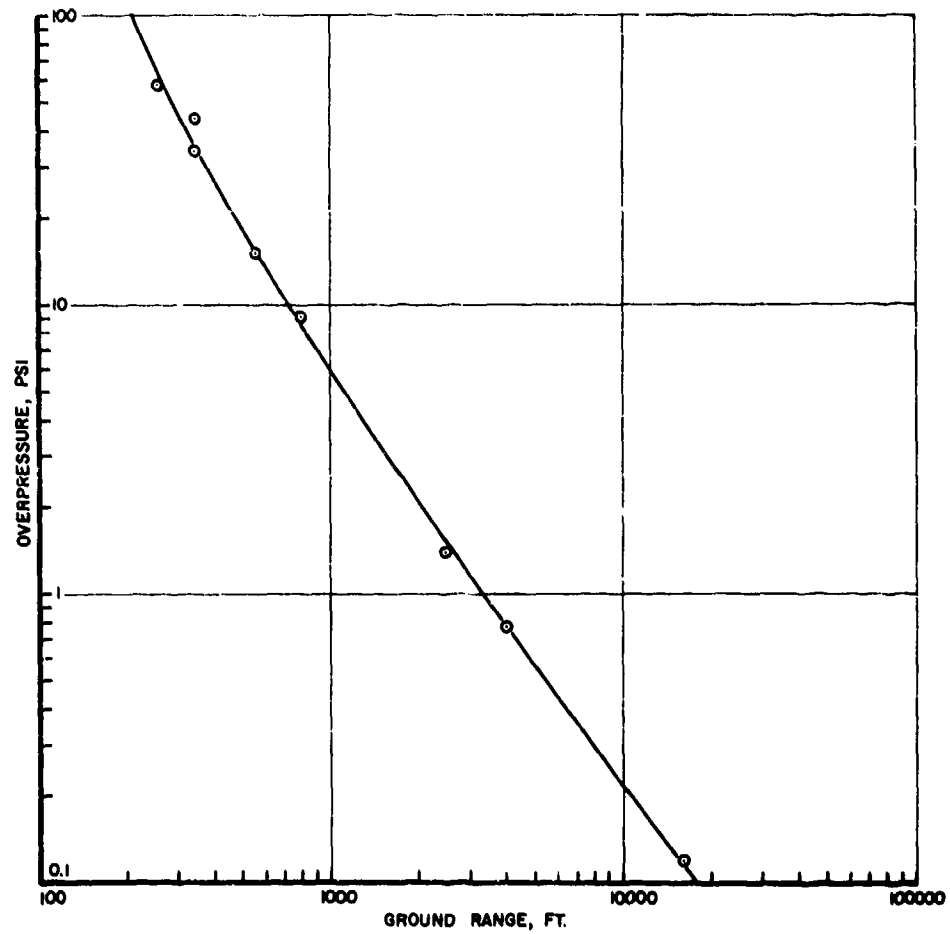


Figure 3.2 Overpressure versus ground range (100 to 0.1 psi).

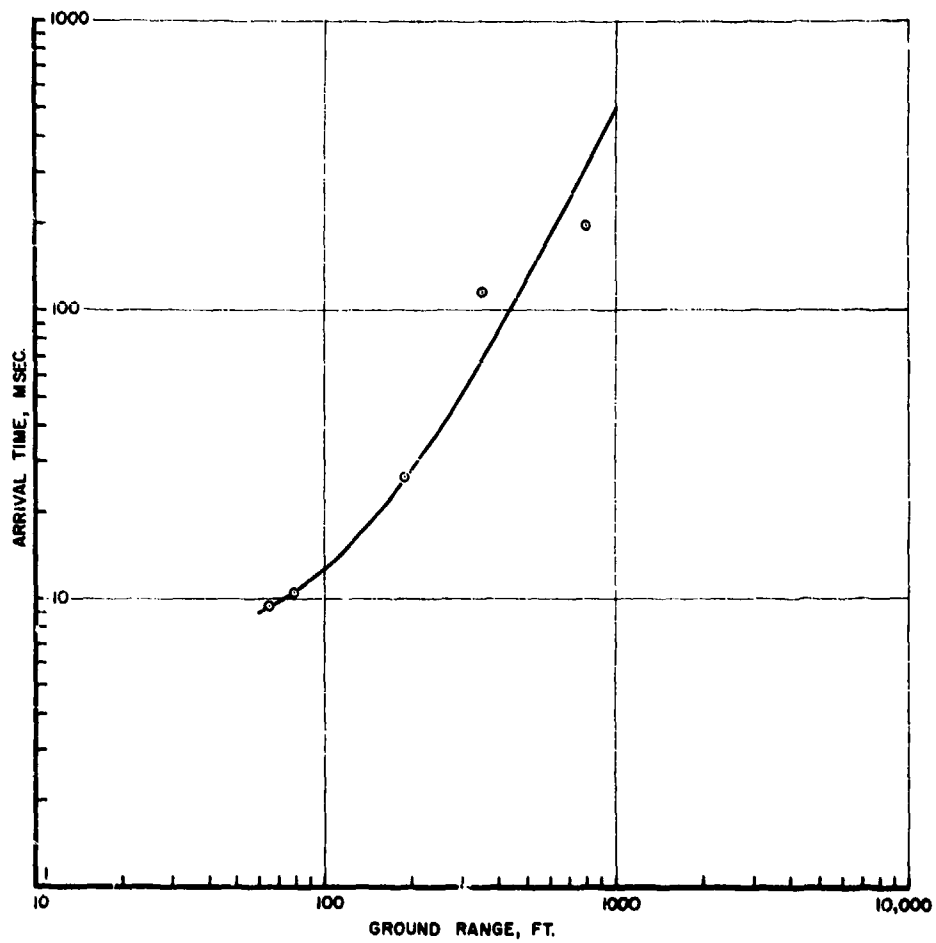


Figure 3.3 Arrival time versus ground range.

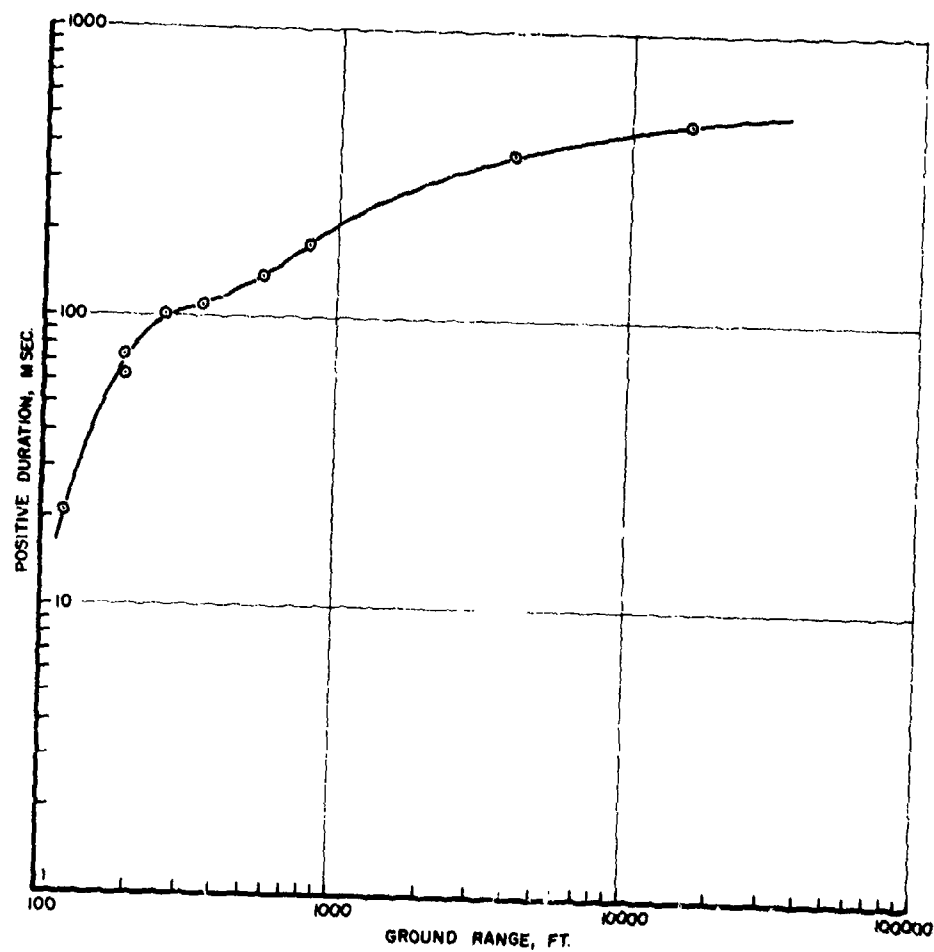


Figure 3.4 Positive duration versus ground range.

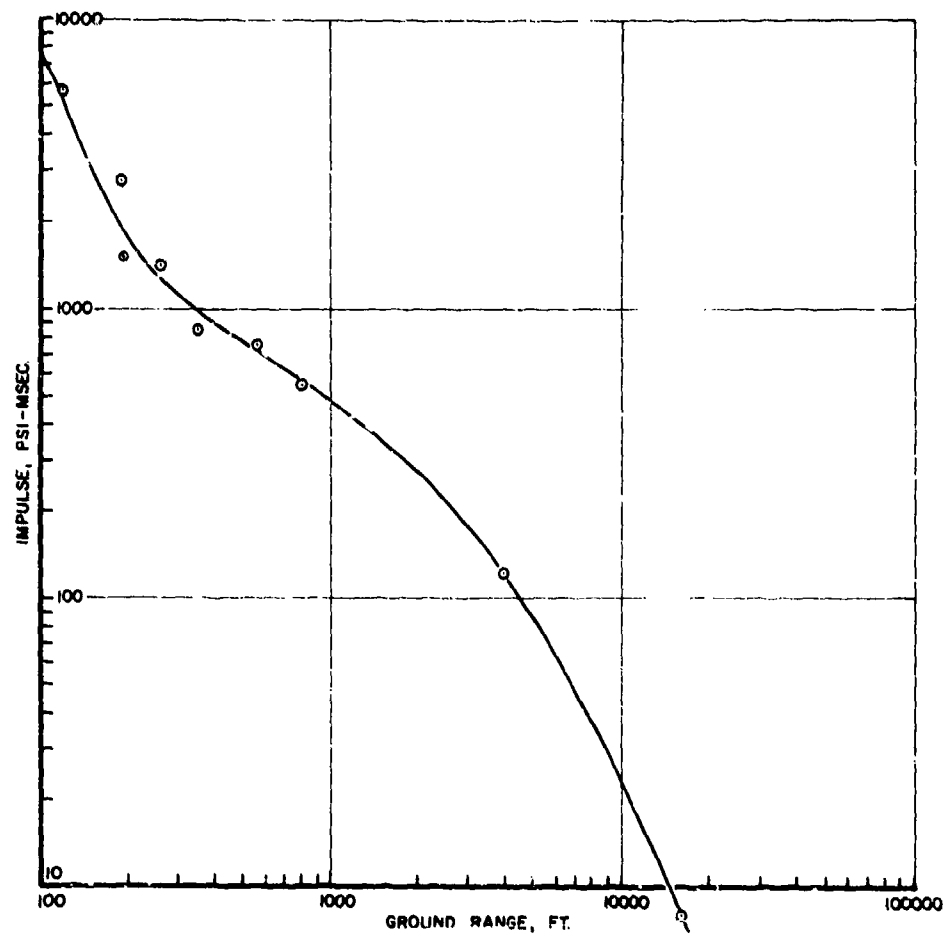


Figure 3.5 Positive impulse versus ground range.

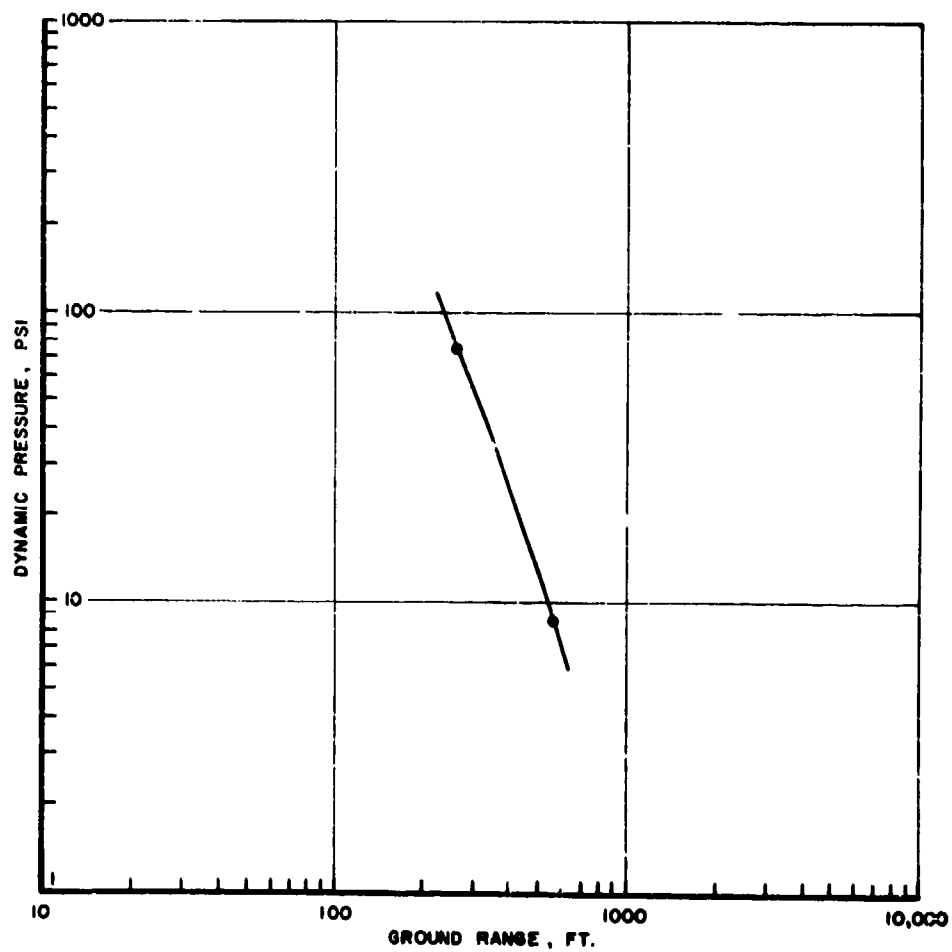


Figure 3.6 Dynamic pressure versus ground range.

## CHAPTER 4

### DISCUSSION AND CONCLUSIONS

The presentation of the discussion of results and conclusions reached will be preceded by a presentation of shot conditions and scaling factors.

#### 4.1 SHOT CONDITIONS AND SCALING FACTORS

The shot conditions for the Johnie Boy shot are listed below:

W = Yield of the device in kilotons = 0.5 ± 0.2  
 DOB = Depth of burial in inches = 23  
 E = Elevation of surface in feet = 5153.52  
 P<sub>o</sub> = Ambient pressure, psi = 12.302  
 T<sub>o</sub> = Ambient temperature, °C = 24.3

It is necessary to normalize air blast data to some standard so that comparisons with other shots can be made. The standard which has been established is a 1-kt radiochemical yield at sea-level ambient pressure of 14.7 psi and ambient temperature of 15° C. The following scaling relations have been accepted as standard.

$$S_p = \frac{14.7}{P_o}$$

$$S_d = \left[ \frac{P_o}{14.7} \right]^{1/3} \left[ \frac{1}{W} \right]^{1/3} = \left[ \frac{1}{S_p W} \right]^{1/3}$$

$$S_t = \left[ \frac{T_o + 273}{288} \right]^{1/2} \left[ \frac{P_o}{14.7} \right]^{1/3} \left[ \frac{1}{W} \right]^{1/3}$$

$$S_i = S_t \times S_p$$

Where:  $S_p$  = pressure scaling factor = 1.1949  
 $S_d$  = distance scaling factor = 1.1869  
 $S_t$  = time scaling factor = 1.2086  
 $S_i$  = impulse scaling factor = 1.4442

#### 4.2 DISCUSSION OF RESULTS

The discussion of results will be limited primarily to comparisons of the data recorded on the Johnie Boy shot to the 1-kt burst on a near ideal surface as presented in DASA-1200 (Reference 3). The measured blast parameters were scaled to a one-kiloton yield and are listed in Table 4.1.

(1) The scaled peak overpressure versus distance values are plotted in Figures 4.1 and 4.2, along with 1-kt curve from DASA 1200. It can be seen in Figure 4.1 that the first two values appear to be in line with an extrapolation of the near-ideal curve, but the succeeding values fall below the curve. The pressure versus time records show non-ideal wave shapes at these stations, but there is some question as to whether the non-ideal wave shapes were because of the depth of burial of the device, a function of the gages, or thermal heating causing a precursor. The device was buried and also a subkiloton yield, so there was no precursor expected. The peak overpressures from 100 psi to 0.1 psi versus distance are presented in Figure 4.2. It should be noted here that the overpressure values remain below the near-ideal curve until approximately 5 psi, where there is a



crossover. This is very similar to Shot Fig of Operation Hardtack (Reference 4), where the overpressure values were lower than the scaled curve in the high and medium pressure range and crossed over the good surface curve at approximately 5 psi. It is quite imperative that on subkiloton shots, such as Little Feller I and II and Johnie Boy, that high response instrumentation be developed for use in the higher overpressure region if valid overpressure versus time records are to be obtained.

(2) The arrival time of the shock front versus distance scaled to 1 kt is presented in Figure 4.3, along with the near-ideal-surface curve from DASA 1200. If one assumes that the datum points are valid, then there is a divergence from the measured points and the 1 Kt values from DASA 1200. The arrival time at Station 1800.29 (949.5 feet) was recorded from a self-recording gage, and there is some question as to its validity since the gage was started at 2 seconds before zero time and there was also a motor start-up time to be accounted for. Measurements made in Reference 5

indicate slightly longer arrival time at their stations than would be predicted from DASA 1200. There is also an inflection in the curve between 300 feet and 500 feet, showing an increase in shock velocity over what might be expected. The BRL data may add validity to the Project 1.2 results, but with the paucity of datum points, a curve was drawn between the last two values.

(3) The positive duration versus distance scaled to 1 kt is presented in Figure 4.4, along with the near-ideal-surface curve from DASA 1200. It should be noted that a wide divergence exists between the two curves from 350 feet to 500 feet. This is the same region in which there appeared to be a change of slope in the arrival time curve. The values measured indicated the positive duration was longer than would be predicted over the scaled distances of from 200 to 500 feet.

(4) The impulse of the positive pressure phase of the blast wave versus distance was scaled to a 1 kt yield and plotted in Figure 4.5 for comparison with the near-ideal-surface curve from DASA 1200. The two curves show similar trends, with the exception of the lower values at distances less than 500 feet. It should be noted that the overpressure values are also lower at the close-in distances and one might expect this to have a greater influence on the positive impulse than the longer durations over a portion of the distances as noted in Figure 4.4. It was stated earlier, and also listed in Table 3.1, that the quality of the records at the close-in stations were poor, fair and non-ideal; therefore, the impulse values plotted in Figure 4.5 should be viewed with these qualifications in mind.

(5) The dynamic pressure measurements have been scaled to a 1-kt yield and plotted in Figure 4.6. There were only two values to report, and the first value appears to be much lower than would be predicted. The scaled values are listed in Table 4.2. As stated previously, these measurements were of poor quality and the results are questionable.

#### 4.3 CONCLUSIONS

Although the project was entered into on a crash basis, meaningful information was obtained and some conclusions reached. The maximum overpressure values measured above 5 psi were lower than the prediction for near-ideal conditions. When the device is placed below the surface, one would expect the overpressure versus distance curve to be lower than one for surface burst conditions, depending on the depth. The overpressure versus distance curve obtained from the Johnie Boy data was lower in the medium pressure range than expected for a 23-inch depth of burial. Lower than predicted overpressure values have been measured from several above surface subkiloton shots at the Nevada Test Site.

When a device is placed below the surface, one would not expect a precursor or non-ideal wave shape to form due to thermal heating of the surface. A non-ideal waveform was recorded at several stations. It is difficult at this time to draw any definite conclusions or make predictions concerning the thermal effects on blast wave propagation from shallow buried nuclear weapons, since this was the first time close-in measurements were made from a shallow-buried device.

TABLE 4.1 SCALED BLAST OVERPRESSURE RESULTS

Station Number	Horizontal Distance	Maximum Overpressure	Arrival Time	Positive Duration	Positive Impulse	Type Gage	Cable or Capsule No.
	ft	psi	msec	msec	psi-msec		
1800.37	77	19118	11.5	---	---	DY	255
1800.36	95	759	12.5	---	---	DY	256
1800.35	142	453	---	25.4	6242	PHS-1S	1000-1176
1800.34	178	277	---	---	---	PHS-1S	800-1131
1800.33	226	165	32.0	74.9	2240	W	253
	226	140	---	88.2	4025	PHS	200-1047
1800.32	309	68	---	122.0	2028	PHS	150-1017
1800.31	415	52.6	140	---	---	W	259
	415	40.6	---	132.9	1215	PHS	100-977
1800.30	665	18.2	---	168.0	1089	PHS	25-1
1800.29	950	10.9	236	217.5	790	PHS	15-704
1800.27	2967	1.67	---	---	---	PHS	15-616
1800.38	4747	0.92	--	449.6	175	PHS	1-1192
1800.39	19140	0.12	---	582.5	11.8	VLP	65
	19140	0.14	---	---	---	VLP	66

TABLE 4.2 SCALED DYNAMIC PRESSURE

Station Number	Horizontal Distance	Dynamic Pressure
	ft	psi
1800.32	309	88.5
1800.30	665	10.1

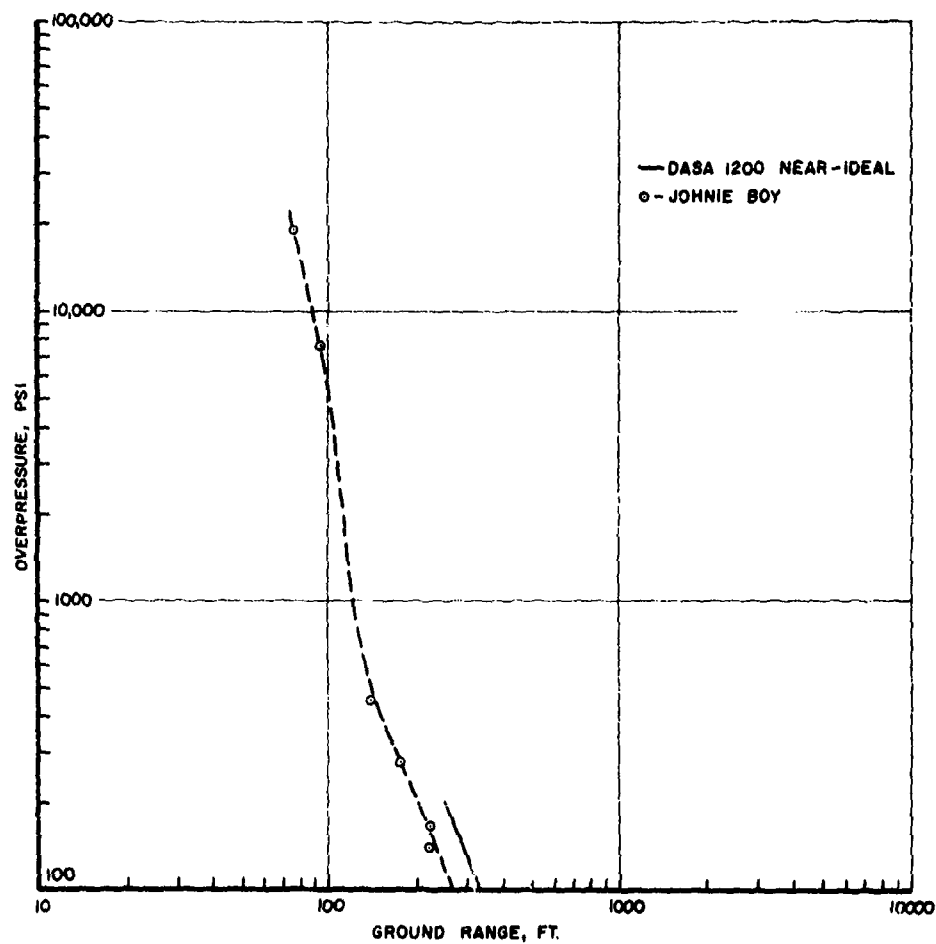


Figure 4.1 Comparison of scaled overpressure versus distance with 1-kt near-ideal curve, high pressure.

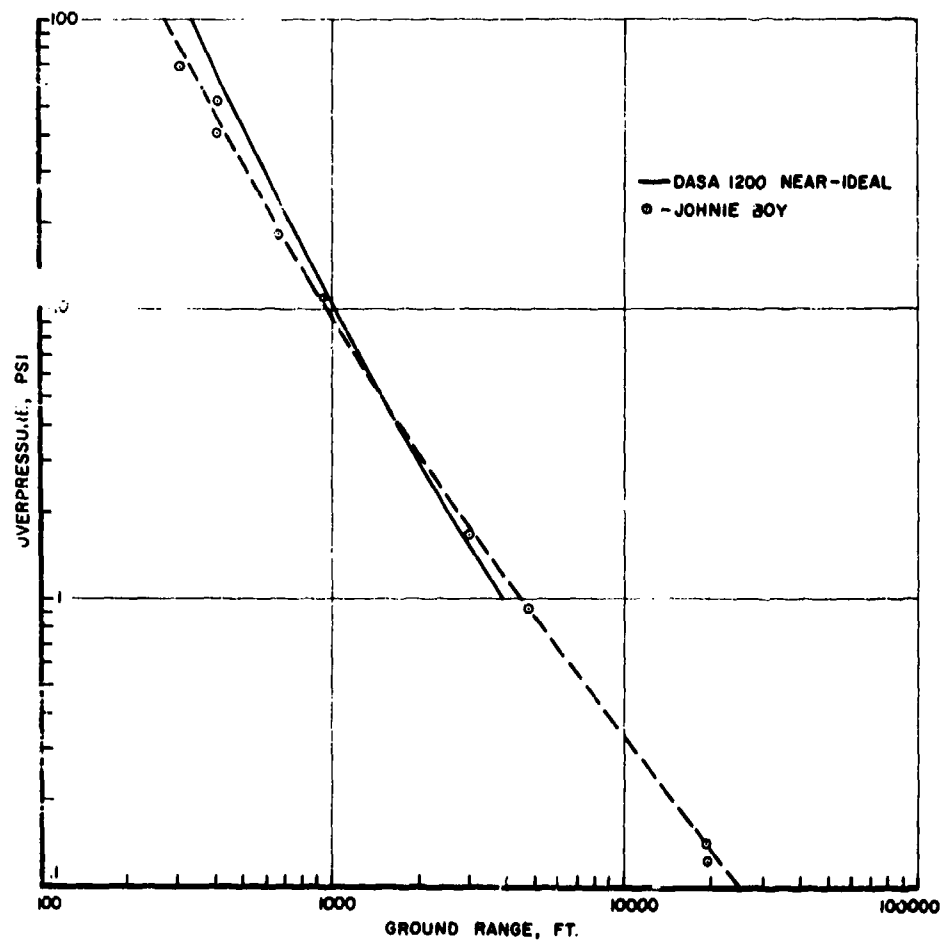


Figure 4.2 Comparison of scaled overpressure versus distance with 1-kt near-ideal curve, medium and low pressure.

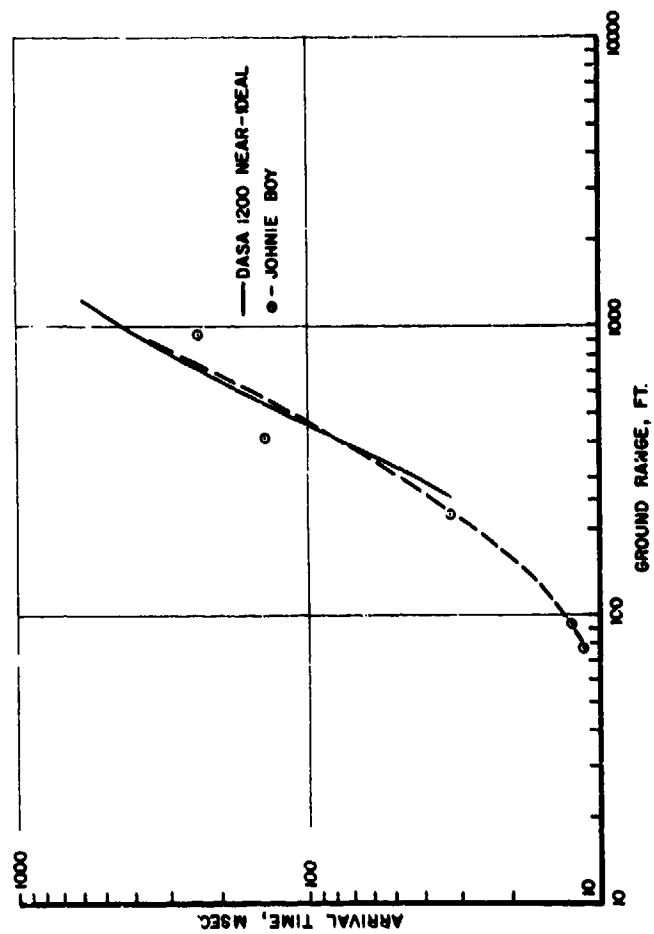


Figure 4.3 Comparison of scaled arrival time versus distance data with a 1-41 year-old curve.

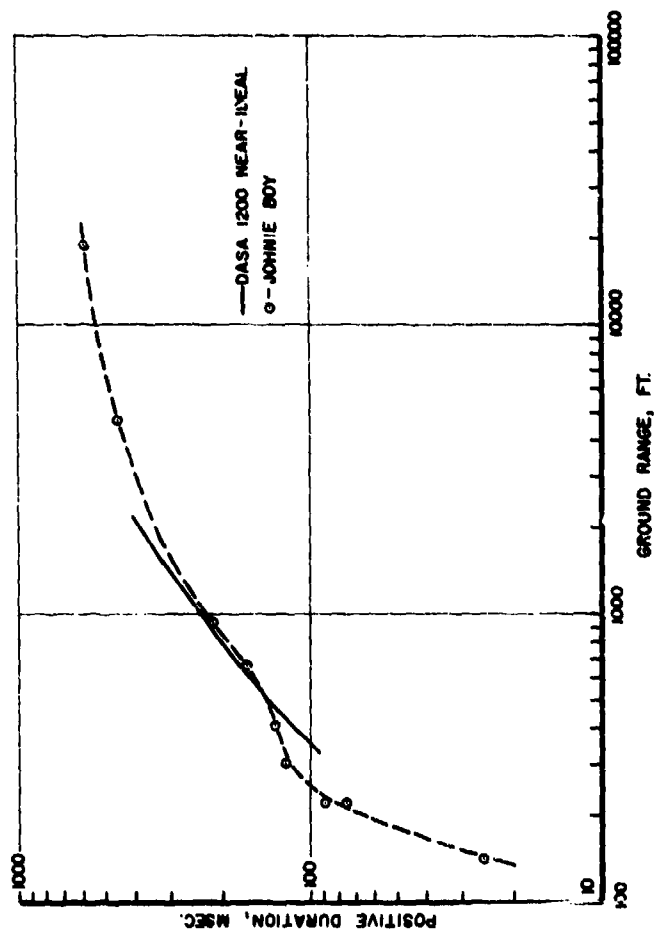


Figure 4.4 Comparison of scaled positive duration versus distance data with a 1-kt near-ideal curve.



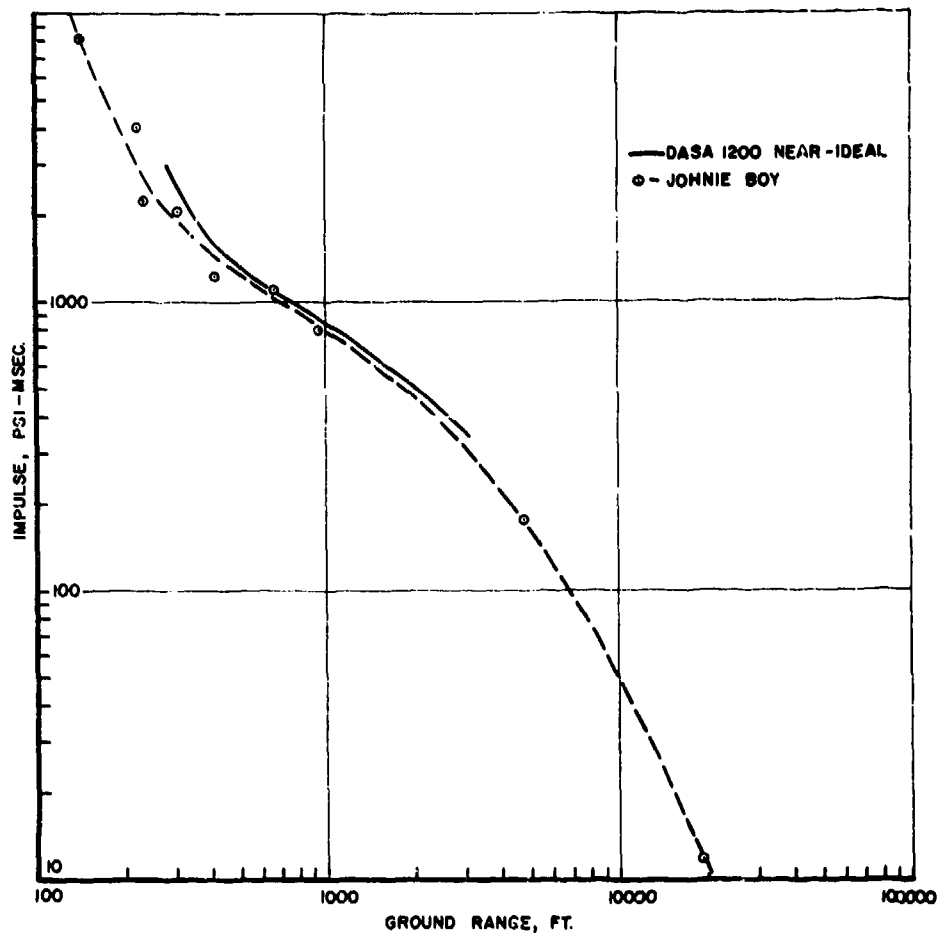


Figure 4.5 Comparison of scaled positive impulse versus distance data with a 1-kt near-ideal curve.

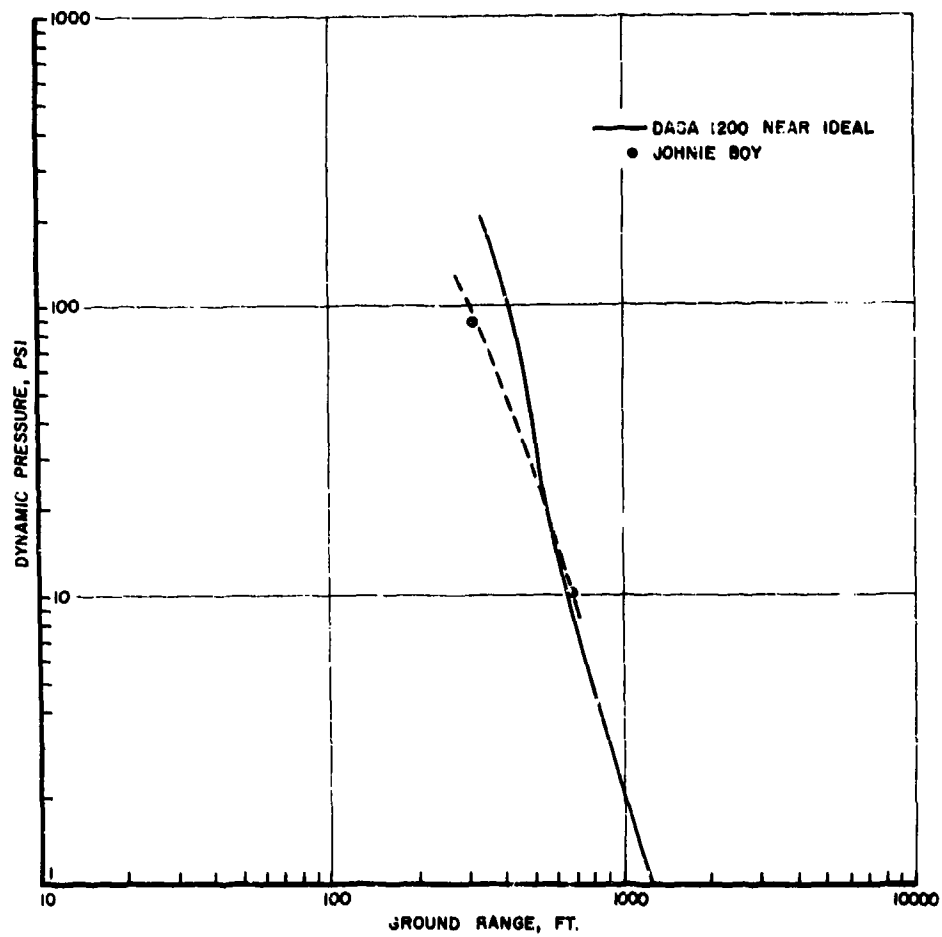
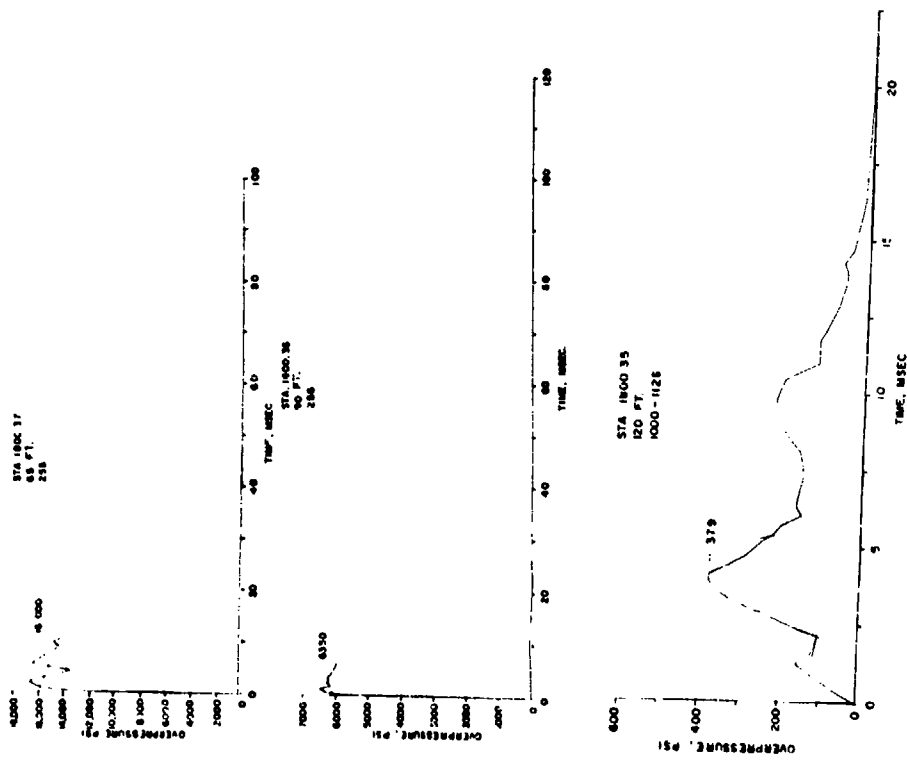
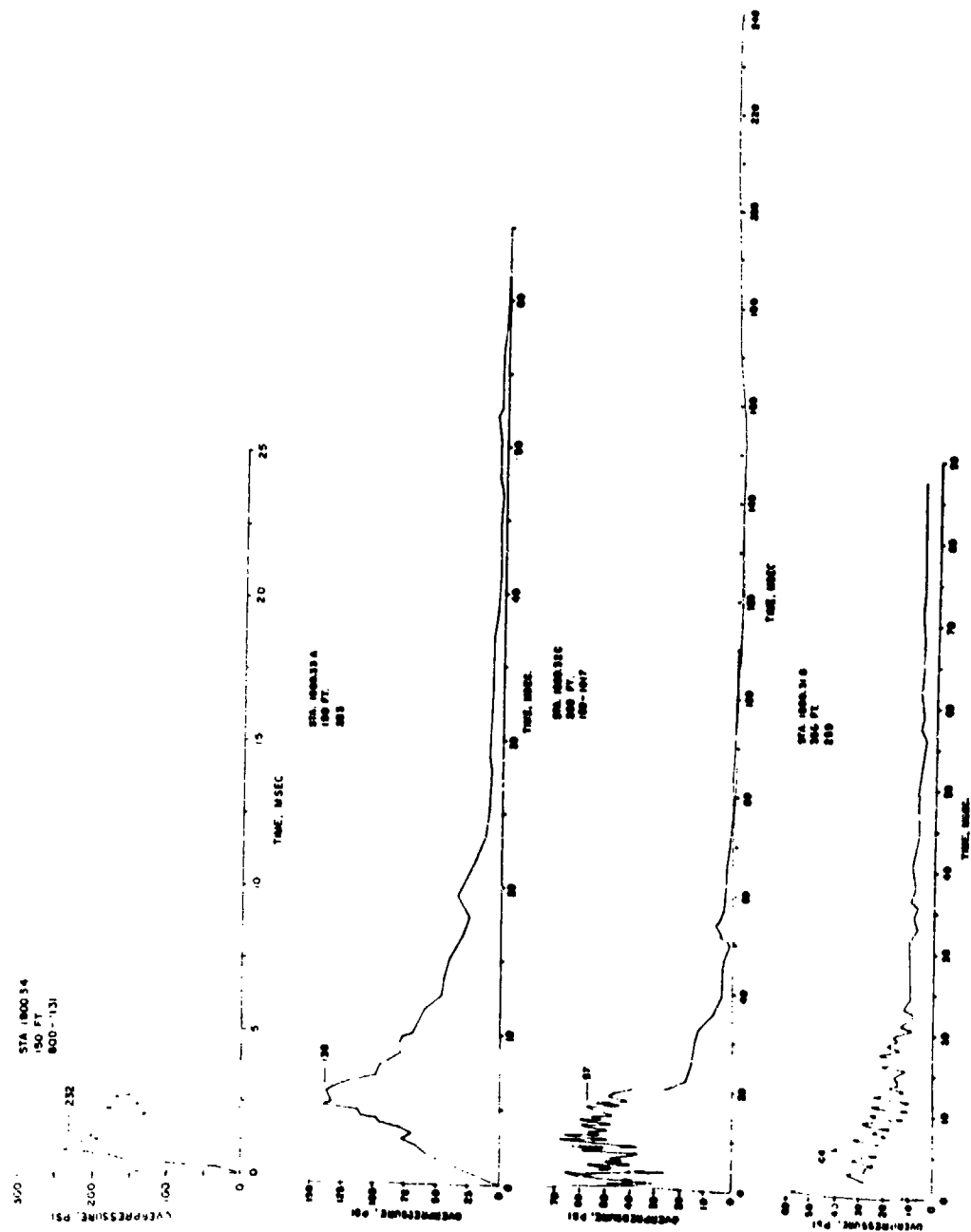
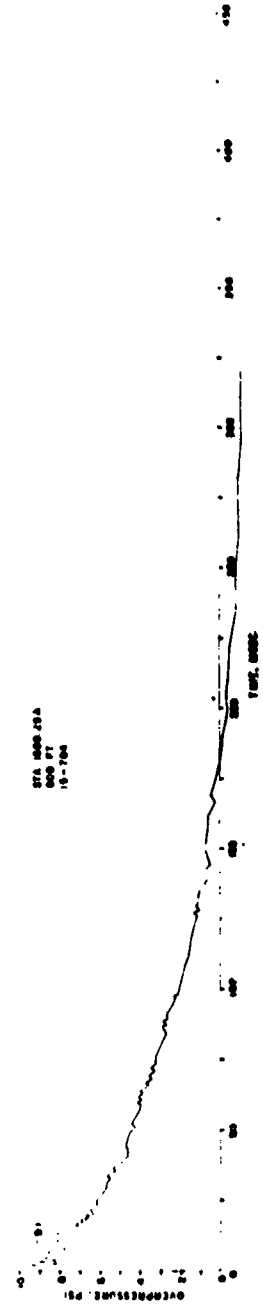
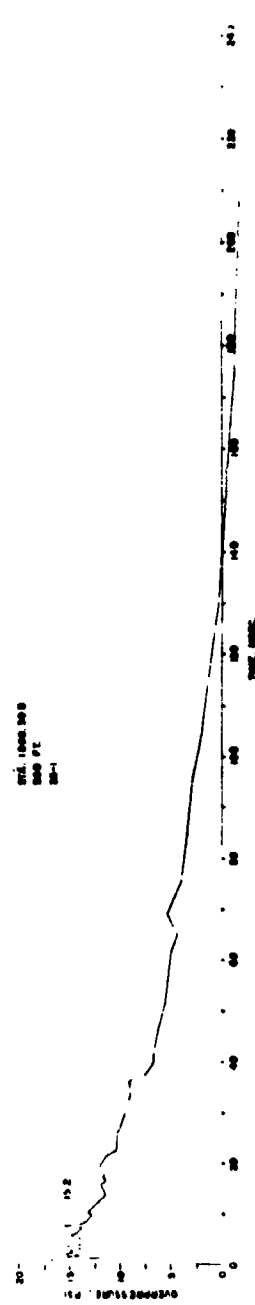


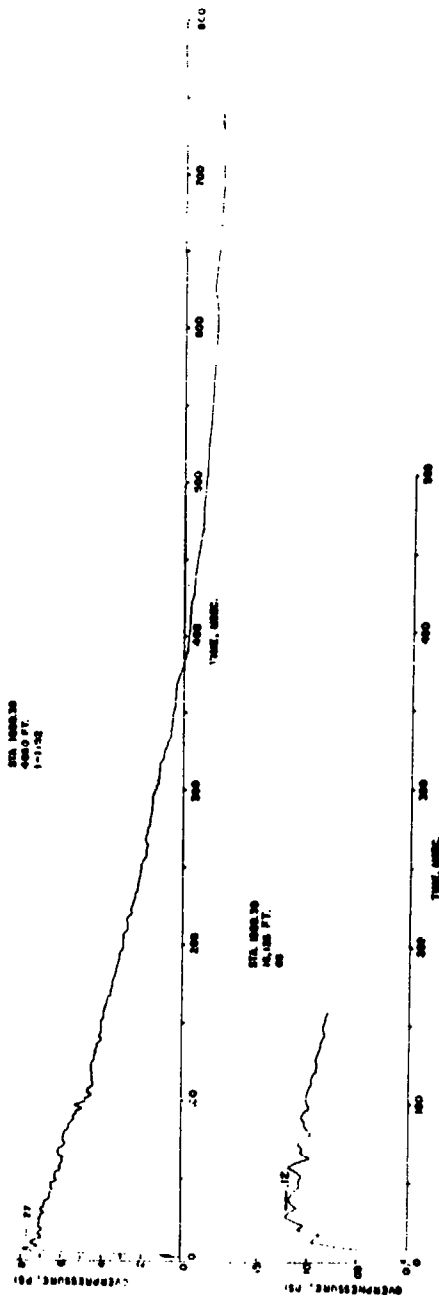
Figure 4.6 Comparison of scaled dynamic pressure versus distance data with a 1-kt near-ideal curve.

APPENDIX PRESSURE-TIME PLOTS









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